QB
4
U33

UNITED STATES NAVAL OBSERVATORY

CIRCULAR NO. 176

U. S. Naval Observatory, Washington, DC 20392 February 1, 1991

U. S. NAVAL OBSERVATORY
JUN 19 1991
LIBRARY

Central Solar Eclipses of 1992

Annular Solar Eclipse of 4–5 January 1992
Total Solar Eclipse of 30 June 1992

by

John A. Bangert

Alan D. Fiala

and

William T. Harris

The U. S. Naval Observatory Eclipse Circulars

Since 1949, the U. S. Naval Observatory has prepared issues of its *Circular* series containing detailed information for observing most total solar eclipses and some annular solar eclipses. This is a service to the international scientific community, based on agreements with Commissions and Working Groups of the International Astronomical Union.

As a regular publication of the U. S. Naval Observatory, distribution is made to institutions with which the Observatory has exchange agreements or other obligation. *No other subscription service is maintained. Users must make a new written request for each eclipse Circular prior to the event.* There is no charge for a single copy. Please address requests to:

Eclipse Circulars
U. S. Naval Observatory
Washington, DC 20392-5100

It is permissible to reproduce any portion of this *Circular*, except for any material noted as having been published elsewhere or prepared by someone who is not a staff member of the U. S. Naval Observatory. It is requested that when any information herein is used for any purpose, that an appropriate acknowledgement of the source be made.

Central Solar Eclipses of 1992

Annular Solar Eclipse of 4–5 January 1992
Total Solar Eclipse of 30 June 1992

U. S. Naval Observatory Circular 176

John A. Bangert
Astronomical Applications Department

Alan D. Fiala
Orbital Mechanics Department

William T. Harris
Astronomical Applications Department

U. S. Naval Observatory
34th St. and Massachusetts Ave., N. W.
Washington, DC 20392-5100
USA

The U. S. Naval Observatory Eclipse Circulars

Since 1949, the U. S. Naval Observatory has prepared issues of its *Circular* series containing detailed information for observing most total solar eclipses and some annular solar eclipses. This is a service to the international scientific community, based on agreements with Commissions and Working Groups of the International Astronomical Union.

As a regular publication of the U. S. Naval Observatory, distribution is made to institutions with which the Observatory has exchange agreements or other obligation. *No other subscription service is maintained. Users must make a new written request for each eclipse Circular prior to the event.* There is no charge for a single copy. Please address requests to:

Eclipse Circulars
U. S. Naval Observatory
Washington, DC 20392-5100

It is permissible to reproduce any portion of this *Circular*, except for any material noted as having been published elsewhere or prepared by someone who is not a staff member of the U. S. Naval Observatory. It is requested that when any information herein is used for any purpose, that an appropriate acknowledgement of the source be made.

CONTENTS

General Information and Explanation of Contents 4
Weather Prospects, *by Jay Anderson* 8

Annular Solar Eclipse of 4–5 January 1992

Overall Eclipse Map, from the *Astronomical Almanac for 1992* 14
Surface Path of the Annular Phase, tabulated by Universal Time (UT) 15
Elements of the Eclipse 16
General Circumstances of the Eclipse 16
Besselian Elements
  Polynomial Form 16
  Tabular Form, tabulated by UT 17
Local Circumstances
  For Points on the Central Line, tabulated by UT 18
  For Geographic Locations (annular and partial phases) 20
Surface Path of the Annular Phase Over Land, tabulated by longitude 24
Corrections to UT and Latitude for Elevations Above Sea Level 27
Path of the Central Line at Flying Altitudes, tabulated by UT 28
Lunar Limb Profile Diagram 30
Detailed Map of the Path Over Land
  Southern California/Northern Mexico 31

Total Solar Eclipse of 30 June 1992

Overall Eclipse Map, from the *Astronomical Almanac for 1992* 34
Surface Path of the Total Phase, tabulated by Universal Time (UT) 35
Elements of the Eclipse 36
General Circumstances of the Eclipse 36
Besselian Elements
  Polynomial Form 36
  Tabular Form, tabulated by UT 37
Local Circumstances
  For Points on the Central Line, tabulated by UT 38
  For Geographic Locations (total and partial phases) 40
Surface Path of the Total Phase Over Land, tabulated by longitude 42
Corrections to UT and Latitude for Elevations Above Sea Level 42
Sky Diagram for Uruguay 43
Path of the Central Line at Flying Altitudes, tabulated by UT 44
Limb Corrections
  Explanation 46
  Lunar Profile Correction Diagrams, *by David Herald*
    Uruguay 47
  Lunar Limb Profile Diagram 48
Detailed Map of the Path Over Land
  Uruguay/Brazil 49
Legend for Detailed Path Maps 50

GENERAL INFORMATION

By coincidence, the two central solar eclipses of 1992 share a similar characteristic: both central paths will pass almost entirely over water, except for a very small portion at one end which will pass over land and include a major city. The first of these eclipses, an annular eclipse of the Sun, will occur on Saturday, 4 January 1992 and Sunday, 5 January 1992. It will be preceded by an associated partial lunar eclipse on 21 December 1991. The central path of this annular eclipse will include a number of small islands in the Pacific Ocean and end over the Los Angeles, California metropolitan area. At maximum over the central Pacific Ocean, approximately 84.4% of the Sun's disk will be obscured. The maximum duration of annularity will be about 11m 36s. Because the track will cross the International Date Line, by local times the eclipse will occur on the morning of 5 January at the beginning of the path and occur on the evening of 4 January at the end of the path. This eclipse belongs to saros series number 141. The last preceding eclipse in this series was the annular solar eclipse of 24 December 1973; the next eclipse in the series will be the annular solar eclipse of 15 January 2010.

The second central solar eclipse of 1992, a total eclipse, will occur on Tuesday, 30 June. It will be preceded by an associated partial lunar eclipse on 15 June. The central path of this eclipse will originate near the mouth of the La Plata River on the eastern South American coast, and will pass over a very small portion of coastal Uruguay and Brazil before entering the South Atlantic Ocean. The capital city of Uruguay, Montevideo, will lie within the central path. The maximum duration of totality, approximately 5m 26s, will occur at a point in the central South Atlantic Ocean. This eclipse belongs to saros series number 146. The last preceding eclipse in this series was the total solar eclipse of 20 June 1974; the next eclipse in the series will be the total solar eclipse of 11 July 2010.

Prior to the annular solar eclipse of 4–5 January 1992, a total solar eclipse will occur on 11 July 1991 over Hawaii, Mexico, Central America, and South America. A partial eclipse of the Sun, visible over extreme eastern Asia, Japan, southwestern Alaska, and the Pacific Ocean, will occur on 23–24 December 1992.

PATH AND VISIBILITY

Inexperienced observers are cautioned to observe only by use of projected images, and not to use any method which would cause them to look directly at the Sun.

ANNULAR SOLAR ECLIPSE OF 4–5 JANUARY. At approximately 21h 16m UT on 4 January 1992, the center of the umbra of the Moon's shadow will touch the Earth at sunrise at a point in the Pacific Ocean east of the Philippine Islands. At this time, the annular phase will last about 7m 14s. Initially, the path will head southward, but later, it will take a turn northward in the equatorial region near the International Date Line. During its passage over the Pacific Ocean, the central path will include a number of small islands. Yap Island and Ulithi Atoll in the Caroline Island group will lie within the path, as will the islands of Arorae, Nikunau, Beru, Tamana, Onontoa, Tabiteuea, Nonouti, Kuria, and Aranuka in the Gilbert Island group. The maximum duration of annularity, approximately 11m 36s, will occur at about 22h 56m UT (4 January) in the equatorial regions of the Pacific Ocean. At this time, approximately 84.4% of the Sun's disk will be obscured and the path will be about 339 km wide. The central path then will head for the Pacific coast of the southern United States. It will pass over San Nicolas, San Clemente, Santa Barbara, and Santa Catalina Islands before the center line leaves the Earth at sunset at 0h 53m UT (5 January) at a point just offshore between Los Angeles and San Diego, California. The northern limit of the central path will end over land, just north of Los Angeles. Neglecting the effects of atmospheric refraction, maximum eclipse will occur at sunset along a curve that runs roughly northwest to southeast through central Los Angeles. On land west of this curve, maximum eclipse will occur just before sunset, but the setting Sun will be extremely close to the horizon. Due to the elliptical shape of the Moon's shadow, locations just east of this curve (including San Diego) will witness second contact, but sunset (ignoring refraction) will occur before maximum eclipse.

Partial phases of the eclipse, of magnitude decreasing with the distance from the path of the central phase, will be visible over Japan, Indonesia, northern Australia, Hawaii, western North America, and most of the Pacific Ocean.

TOTAL SOLAR ECLIPSE OF 30 JUNE. The center of the umbra of the Moon's shadow will touch the Earth at sunrise at a point along the eastern coast of South America near the mouth of the La Plata River at approximately 11h 02m UT. At this time, totality will last approximately 2m 58s. The central path will head northeastward where it will make its only landfall over a very small portion of Uruguay and an even smaller portion of Brazil. Only the northern half of the path will pass over land, as the center line and southern limit will lie just offshore. In Uruguay, the cities of Montevideo and Minas will lie close to the northern limit. Maldonado, San Carlos, and Rocha will lie just to the north of the center line. In Brazil, the town of Santa Vitoria do Palmar will lie near the northern limit. As seen from all of these locations, maximum eclipse will occur very soon after sunrise with the Sun very close to the horizon throughout the total phase of the eclipse. After leaving Brazil, the central path will continue northeastward over the South Atlantic Ocean. Approximately midway between South America and Africa, the path will take a turn to the southeast, passing just to the west of the southern tip of Africa. The center line will leave the Earth at sunset at 13h 19m UT at a point over open water midway between the southern tip of Africa and Antarctica.

Partial phases of the eclipse, of magnitude decreasing with the distance from the path of the central phase, will be visible over central South America, southwestern Africa, and the South Atlantic Ocean.

CHANGE IN CONTENTS

Detailed maps are provided for the central path over major land areas; specifically, at the end of the path for the 4–5 January eclipse and at the beginning of the path for the 30 June eclipse. All of the maps are on the same scale (see *Detailed Path Maps* below). No maps are provided for the path of the 4–5 January eclipse through the Pacific Ocean islands; however, for observers interested in plotting this path themselves, coordinates are provided in the table, *Surface Path of the Annular Phase Over Land*. Continuing a change made in *Circular 173*, the tables giving the central path as a function of longitude at flying altitudes have been replaced by tables providing the path of the central line at flying altitudes as a function of time. No refraction corrections have been applied in the tables of local circumstances for geographic locations. All locations are assumed to be on the surface of the reference ellipsoid, except for the observatories, whose heights were included in the calculations (see *Local Circumstances* below). No sky diagrams or limb correction diagrams are provided for the 4–5 January (annular) eclipse.

PARAMETERS AND CORRECTIONS

The predictions in this *Circular* are derived from the solar and lunar data contained in the DE200/LE200 ephemeris developed jointly by the Jet Propulsion Laboratory and the U. S. Naval Observatory for use in the *Astronomical Almanac* for 1984 and after. In order to best take into account the rough limb of the Moon, the value of $k = 0.2725076$ for the ratio of the radius of the lunar profile to the Earth's radius is used throughout the calculations. The International Astronomical Union (IAU) adopted the new value for k in August 1982. Along with that value, corrections have been applied to both lunar latitude and longitude to help account for the difference between the center of figure and the center of motion (see *Elements of the Eclipse* elsewhere in this *Circular*). It is expected that the observer will then make the final limb corrections, as described elsewhere in this *Circular*. As usual, all time arguments are in Universal Time (UT), using the best value of ΔT [the difference between Terrestrial Dynamical Time (TDT) and UT] available at the time of preparation (see *Elements of the Eclipse*). The convention of longitude positive east is used throughout this *Circular*.

DETAILED PATH MAPS

The detailed maps provided in this *Circular* are presented on portions of the Defense Mapping Agency's Operational Navigation Charts (ONC), scale 1:1,000,000, Lambert Conformal Conic Projection. All of the maps have been reduced to 50% of original size, enlarging the scale from 15.78 miles/inch to 31.56 miles/inch. For an explanation of the maps, see *Estimating Second and Third Contacts* below.

LOCAL CIRCUMSTANCES

DEFINITIONS. *First* and *fourth contacts* are, respectively, the beginning and the end of the partial phase. *Second* and *third contacts* are, respectively, the beginning and end of the central phase, if it occurs at the given location. *Duration* is the time interval between second and third contacts. Dot leaders indicate that a phenomenon occurs below the horizon for a given location.

The *position angle* of a point of contact on the solar limb is measured eastward (counterclockwise) around the solar limb. *P* is the position angle measured from the north point on the limb; *V* is the position angle measured from the vertex point. The *north point* lies on the great circle arc drawn from the north celestial pole to the center of the solar disk; the *vertex point* lies on the great circle arc drawn from the zenith to the center of the solar disk. If the angle is listed as negative, add 360°.

The *azimuth* of the Sun is measured along the horizon clockwise from the north point eastward to the foot of the great circle arc drawn from the zenith through the center of the solar disk down to the horizon. If it is listed as negative, either add 360° or measure westward from north.

The *magnitude* of the eclipse is the fraction of the apparent diameter of the solar disk covered by the Moon at the time of greatest phase, expressed in units of the solar diameter.

Degree of obscuration is the fraction (per cent) of the area of the apparent solar disk obscured by the Moon at maximum eclipse.

TABLES. In addition to the table of local circumstances on the center line, a table of accurate local circumstances for a list of selected geographic locations is provided for each eclipse. The locations were chosen for their position near the central path, general geographic distribution, and size of population. Coordinates were taken from *The Times Atlas* or read from the detailed maps in this *Circular*. All coordinates are approximate and assumed to be on the surface of the reference ellipsoid, except for the tabulated observatories, whose coordinates (including height) were obtained from the *Astronomical Almanac's* observatory list. The printed circumstances correspond to the printed coordinates, in case there should be an error in identification or coordinates. It is often difficult in preparing maps and local circumstances to ascertain the correct name and spelling for a given location. *Therefore, the information presented here is for location purposes only; it is not authoritative, and does not imply recognition of the status of any area by the United States Government*. The tabulated local circumstances are not corrected for refraction. For the user who wishes to calculate local circumstances, the elements of conjunction, general circumstances, and Besselian Elements for UT arguments are provided. The Besselian Elements are given as usual in tabular form, and also in polynomial form. Precepts for the calculations of local circumstances can be found in the Explanation of the *American Ephemeris and Nautical Almanac* for 1980 or earlier years.

ESTIMATING FIRST AND FOURTH CONTACTS. Beginning and end of the partial phase, or first and last contacts, can be estimated using the one-page overall map of each eclipse reproduced in this *Circular* from the *Astronomical Almanac*. The dashed lines show the surface outline of the Moon's penumbra at a time interval of 30 minutes. The short dashes show the leading edge, the long dashes show the trailing edge. First contact occurs when the leading edge passes over the location in question, last contact occurs when the trailing edge passes. Duration is the time difference between contacts. The time halfway between is the middle of the eclipse. This is near the time of maximum eclipse, but not necessarily identical. At a given location, one need only estimate the intermediate position of the penumbra's edge between the starting and ending lines on either side and thus the time of the contact. For observers within the elongated "teardrop" curves to the extreme east and west, part of the eclipse occurs below the horizon.

ESTIMATING SECOND AND THIRD CONTACTS. Low precision times of second and third contacts in the central path can also be estimated. The central paths over land for each eclipse are shown on a series of detailed maps in this *Circular*. On the maps, the heavy solid lines mark the northern and southern limits of the predicted path. Each dashed line represents the projection of the diameter of the umbra, joining the northern and southern limits and central point for the indicated instant, at which all points on the dashed line experience maximum eclipse. Elsewhere in the *Circular* are tables of local circumstances for points on the central line. Use the maps and tables as follows: Find on the maps the location in the path for which you want local circumstances. From the one-minute cross lines on either side, estimate or measure the time t_0 when the projected axis line of the umbra will pass over the point. Turn to the table of *Local Circumstances for Points on the Central Line* for the eclipse of interest. Find where the time t_0 fits into the first column on each page. Using the appropriate fraction of the time interval, read across both pages and interpolate the times of second and third contacts, the duration (D), and the width of the path (a). Make a note of the angles P and V for each contact (for use as described in the next section), and also the altitude (a) and the azimuth (A) of the Sun at maximum eclipse. Turn back to the map. If you mark the cross lines for the second and third contact times, you can see the breadth of the projected shadow. Now draw a line through the observing point perpendicular to the path. Estimate or measure how far the point is from the center of the path and call this quantity b (a and b must be in the same units). Next compute the approximate duration (T) for the selected location by:

$$T = D\sqrt{1 - (2b/a)^2}$$

Then, the time of second contact is approximately $t_0 - T/2$, third contact $t_0 + T/2$.

ESTIMATING POSITION ANGLES. Lunar limb profiles for these eclipses are provided elsewhere in this *Circular*. For locations in the central path, the predicted times and position angles of contacts are based on the Moon's mean limb (the smooth circle in the limb profile diagrams). Correction for limb irregularities is discussed in the text accompanying the 30 June profile. In working with this construction, remember that the position angles are given for the solar disk, which is observable, but corrections are based on features on the lunar disk, shown in the diagram. The two nearly coincide between second and third contacts, so it is adequate to plot angles pertaining to the Sun on the lunar diagram. However, this is not the case for first and fourth contacts. You may find it convenient to use a transparent overlay with a circle of radius three inches.

For each second or third contact to be sketched for a location given in a table, take from the table the time of contact (t_c), the angles P and V, and the altitude (a) and the azimuth (A) of the Sun at maximum eclipse, as described above. Convert the time of contact to hours and decimals. The topocentric position angle of the lunar axis (C) is a function of time, the position of the Moon and the Sun, and the location of the observer. For these eclipses, compute C from the following equations. For the 4–5 January annular eclipse:

$$C = 0°.50 - 0°.21\, t_c + 0°.42 \cos a \sin (P - V).$$

In this equation, if t_c occurs on 5 January, then $t_c = t_c + 24$ hours. For the 30 June total eclipse:

$$C = 359°.08 + 0°.26\, t_c - 0°.43 \cos a \sin (P - V).$$

On the diagram, N marks lunar north. Using the four direction tick marks, find the center of the circle. Draw a line from the center through N. Next measure the angle C westward (clockwise) from N. Mark the point on the mean limb and draw a line from the center through it. This points to the Earth's north celestial pole. From this line, measure back the angle P eastward (counterclockwise) to find the point of contact on the mean limb. Draw a line from the center out through that point. Finally, from that line, measure through the angle V westward (clockwise). Draw a line from the center through this point. This line points to the observer's zenith. Now you can visualize events as follows: Facing in the direction of the Sun's azimuth (A), measured in degrees positively from the north point of the horizon around clockwise to the east, hold the diagram up at arm's length at the altitude (a) of the Sun at maximum eclipse, and turn it so that the line pointing to the zenith points straight up. The line to the north point of the disk will point to celestial north for the observing site, and the point of contact at the limb will be at its correct apparent orientation.

To get position angles for locations not listed in the tables, follow the directions given above for estimating second and third contacts, and plot the points of second and third contacts for the interpolated (P,V) *on the center line*. Draw a line connecting the two contacts on the mean limb. It should pass through the center of the disk in approximately an east/west direction. In order to transfer this line of motion to a parallel one for a point off the center line, draw or construct a perpendicular diameter, which runs approximately north/south. Taking (2b/a) from the calculation of duration, measure off (2b/a) × radius from the center of the circle along the north/south diameter in the same direction as the observing site is from the center line. Mark the point on the diameter, and draw or construct perpendicular to it, another line parallel to the line through the central line contact points. This new line will intersect the mean limb at approximately the points of contact. The western point is for second contact, the eastern is for third contact. This construction is not as accurate as a full calculation, but adequate for field estimates.

OBSERVATIONS

Precise observations of the second and third contact times, at any part of the path, but especially the northern and southern limits, are needed and requested. Since precise coordinates of the observer must be determined, reports of such timings should indicate location information, such as nearest settlement, roads to the site, distance to nearby landmarks or identifiable buildings and the nearest road intersection, distance from the center of the road, etc. The method of timing also should be described. Precision requirements are to within 0.5 second of time and 50 feet in location. Please send reports to:

Orbital Mechanics Department
U. S. Naval Observatory
Washington, DC 20392-5100 USA

Inexperienced observers are cautioned to observe only by use of projected images, and not to use any method which would cause them to look directly at the Sun.

Information on photography, direct viewing, and projection methods may be found in the following publications:

"Safe Solar Filters," by B. Ralph Chou, *Sky & Telescope*, August 1981, p. 119.

"Observing the Sun in Safety," by J. C. D. Marsh, *J. Brit. Astron. Assoc.*, 1982, 92, 6, p. 237.

Astrophotography Basics, Kodak Customer Service Pamphlet P-150, 1988.

A Complete Manual of Amateur Astronomy, by P. Clay Sherrod, Prentice-Hall, 1981.

Eclipse, by Bryan Brewer, 1979.

Observe: Eclipses, by R. Sweetsir and M. Reynolds, Astronomical League, 1979.

ACKNOWLEDGEMENTS

The weather prospects section was contributed by meteorologist Jay Anderson of the Prairie Weather Centre; Winnipeg, Manitoba, Canada; (204) 983-4513.

The charts to correct contact times for the effects of lunar limb features were contributed by David Herald, Canberra, A.C.T., Australia.

The detailed maps are presented on portions of the Defense Mapping Agency's (DMA) Operational Navigation Charts (ONC) G-18 and H-22 (4–5 January eclipse) and R-24 (30 June eclipse). Information concerning availability, purchase prices, and ordering instructions can be obtained by calling DMA at 1-800-826-0342 from anywhere in the continental United States, (301) 227-2495 from elsewhere, or by writing:

Director
Defense Mapping Agency CSC
ATTN: PMA
Washington, DC 20315-0010 USA

The lunar limb profile charts were prepared using software subroutines from the occultation program of the U. S. Naval Observatory.

The following specific contributions were made by members of the U. S. Naval Observatory staff:

William Harris prepared the overall line map and the detailed maps of the path over land.

The polynomial representation of the Besselian elements was programmed by Dr. LeRoy Doggett.

WEATHER PROSPECTS

Jay Anderson
Prairie Weather Centre
900-266 Graham Ave
Winnipeg, MB CANADA R3C 3V4

ANNULAR: 4–5 JANUARY 1992

The first eclipse of 1992 begins in equatorial regions of the western Pacific and arcs southward to spend a brief moment in the southern hemisphere before turning toward the North American coast. For the first half of its journey the weather is tropical-generous amounts of convective cloud, warm temperatures, and frequent rainfalls. It ends in the sub-tropical winter of California, where drier skies promise the best viewing prospects of the setting Sun.

Figure 1 shows the mean monthly cloud cover along the eclipse track as determined by researchers at the University of Leningrad and the Soviet Hydrometeorological Research Institute. The cloud cover statistics were extracted from U.S. and Soviet satellite images between 1971 and 1980, and compiled in 5° latitude by 10° longitude bins. While the resolution of the data is not capable of showing fine scale details of the world's cloud cover, it provides an excellent description of the larger features, particularly over the oceans.

The eclipse track crosses the Intertropical Convergence Zone (ITCZ) on its southward leg and again as it turns back to the north. The ITCZ is the region where the winds from the northern and southern hemispheres converge, creating a region of heavy cloud cover and frequent precipitation. At this time of year the ITCZ over the central Pacific is weak and fragmented, with a relatively meagre increase in associated cloudiness.

After leaving the ITCZ for the second time, the eclipse track heads across the sunnier trade wind belt past Hawaii and then moves into the cloudiest portion of its path. The eastern Pacific between Hawaii and California is home to an extensive area of low level cloud and fog which is created by high levels of water vapour trapped under the subsiding winds of the high pressure cell which dominates these waters. Cloud-creating processes are aided by cool ocean currents along the coast.

The cloud cover is often carried inland by winds along the California coast, as evident in Figure 2 which shows that skies tend to be sunniest to the east of the coastal mountains which block the cool and moist flow off the Pacific. Urban haze also plays a part in restricting the frequency of good visibility, so that the best areas to watch the setting ring of sunlight will be found on the offshore islands. In spite of all this, cloud cover in California is the least of any of the land based parts of the shadow's route and there are good prospects for a view of this sunset spectacle. Table 1 gives top marks to San Clemente Island, which, lying slightly to the west, is also more deeply embedded in the final moments of the eclipse's central path.

TOTAL: 30 JUNE 1992

When it comes to access, the second eclipse of 1992 has a distinct similarity to the first. Both occur almost completely over water, and both have their best weather prospects on the tiny portion which touches land. In the case of the June eclipse, it's unfortunate that such a long event should take place mostly over water where the cloud cover statistics are so discouraging. June is at the height of the southern hemisphere winter, when the mid-latitude storm track is closest to the equator, and cloud cover is at its heaviest along the shadow's course.

The main control on the weather patterns is the position of the sub-tropical anticyclone which lingers over the south Atlantic. At this time of year the anticyclone lies just north of the 30th parallel of latitude and is crossed only by the most northerly portion of the eclipse track. Although the Earth's great high pressure cells are normally associated with sunny skies, the effect is mostly confined to their equatorial side, and the 1992 event remains too far south to tap the clearest weather.

Figure 3 shows the mean cloud cover as determined by Soviet researchers from U.S. and Soviet satellites (described in the January eclipse discussion). The eclipse track skirts the edge of the sunniest skies during the first half of its oceanic voyage, and then moves into a zone of heavy cloud cover which distinguishes the southeastern Atlantic along the African coast. The best prospects are at the beginning of the path, on land in Uruguay and Brazil. Figure 4 shows the frequency of scattered cloud at 9 a.m. along the tiny land based portion of the track. While cloud statistics are not optimistic, the best parts are those which are closest to the centre line and along the coast, either at Maldonado or La Paloma. The lower frequency of sunny weather farther inland is due to the hills of the Cuchilla Grande which intercept the moist flow off the Atlantic and lift it to form a region of heavier cloud.

The frequency of low cloud and fog at eclipse time is at its annual high along the coastal areas of Uruguay in June (Table 2). Low clouds come with fewer holes than other types, and because the eclipse is so low to the horizon, any cloud present will appear even heavier because of perspective effects. For this reason shipboard observers may have better prospects for seeing the Sun even though the cloudiness shown in Figure 3 is slightly heavier over the water than on land. Ships have the advantage of mobility, and can be positioned well offshore to take advantage of the higher sun angle to reduce the effects of perspective on the apparent amount of cloud. Mean wave heights range between 1.5 and 2 metres over the morning portion of the track and then rise to a peak of 3.5 metres in the windy waters south of Cape of Good Hope. Photography may require fast film and reflexes in order to capture the Sun from an ocean location.

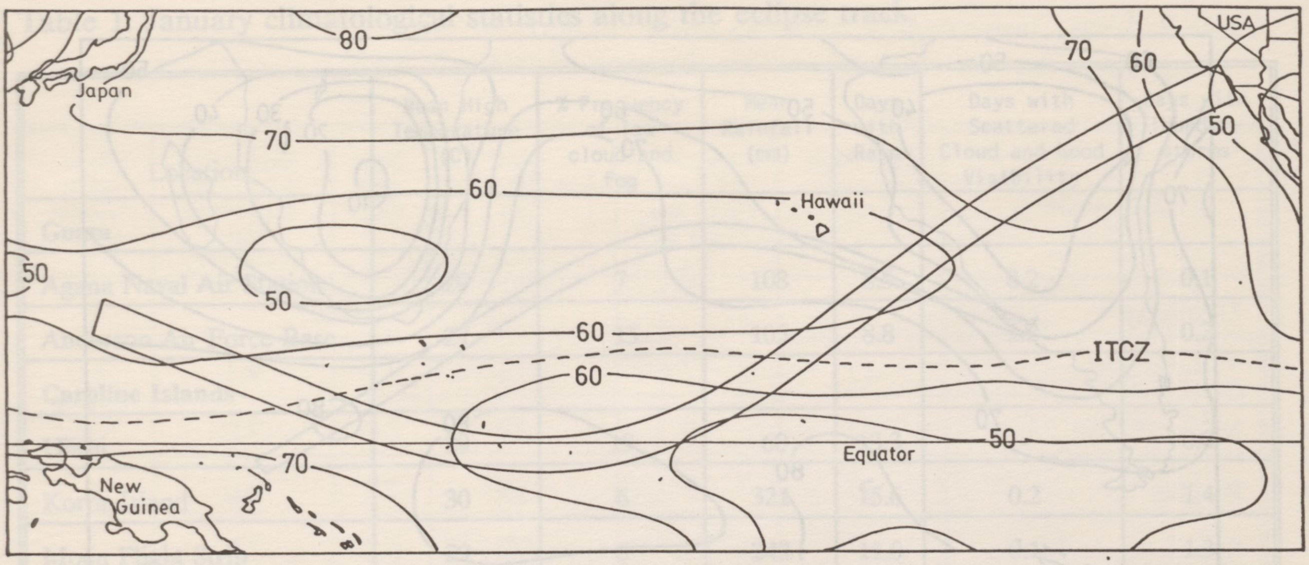

80
Japan
70
60
Hawaii
50
50
60
ITCZ
60
50
Equator
70
New Guinea
USA
70
60
50

Figure 1: Mean January cloud cover in percent from 1971 - 1980 as determined from satellite images. The Intertropical Convergence Zone (ITCZ) is marked with a dashed line.

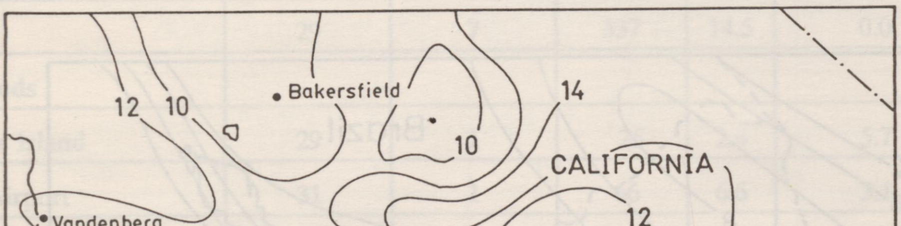

12
10
Bakersfield
10
14
CALIFORNIA
12
Vandenberg
Victorville
Santa Barbara
Burbank
Los Angeles
Riverside
Long Beach
North limit
10
14
10
San Nicolas Is.
San Clemente Is.
San Diego
10
Tijuana
MEXICO
12
Ensenada
Centre line of Eclipse
South limit
14

Figure 2: Mean number of days in January with scattered cloud (less than 3 tenths) and good visibility (3 miles or more) at eclipse time. The eclipse track is approximate.

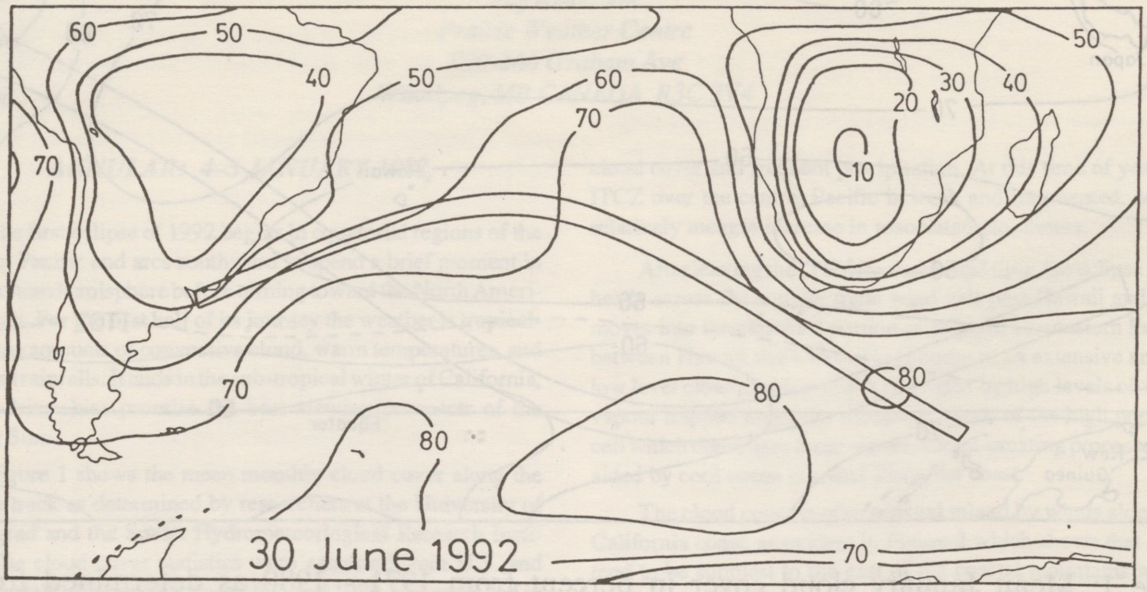

60
50
40
50
60
70
70
70
80
80
80
10
20
30
40
50
70
30 June 1992

Figure 3. Mean June cloud cover in percent, as in figure 1.

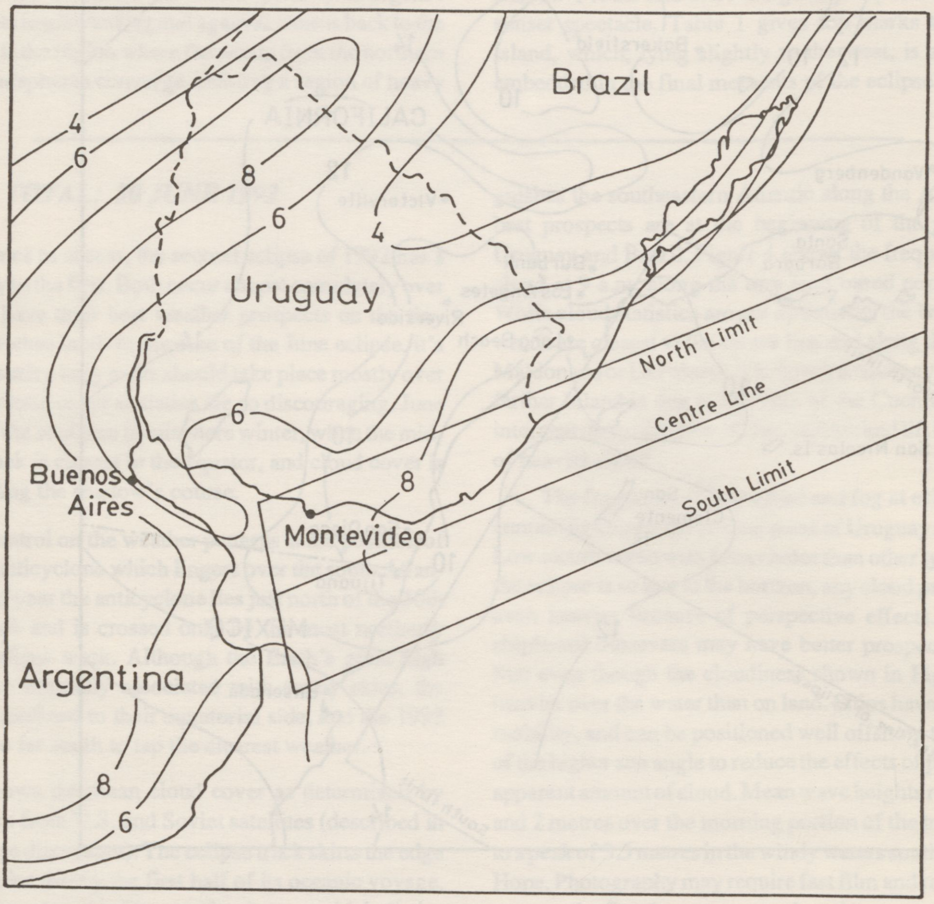

Brazil
4
6
8
6
4
Uruguay
North Limit
Centre Line
South Limit
6
8
Buenos Aires
Montevideo
Argentina
8
6

Figure 4. Mean number of days in June with scattered cloud and good visibilities at eclipse time, as in figure 2.

Table 1: January climatological statistics along the eclipse track.

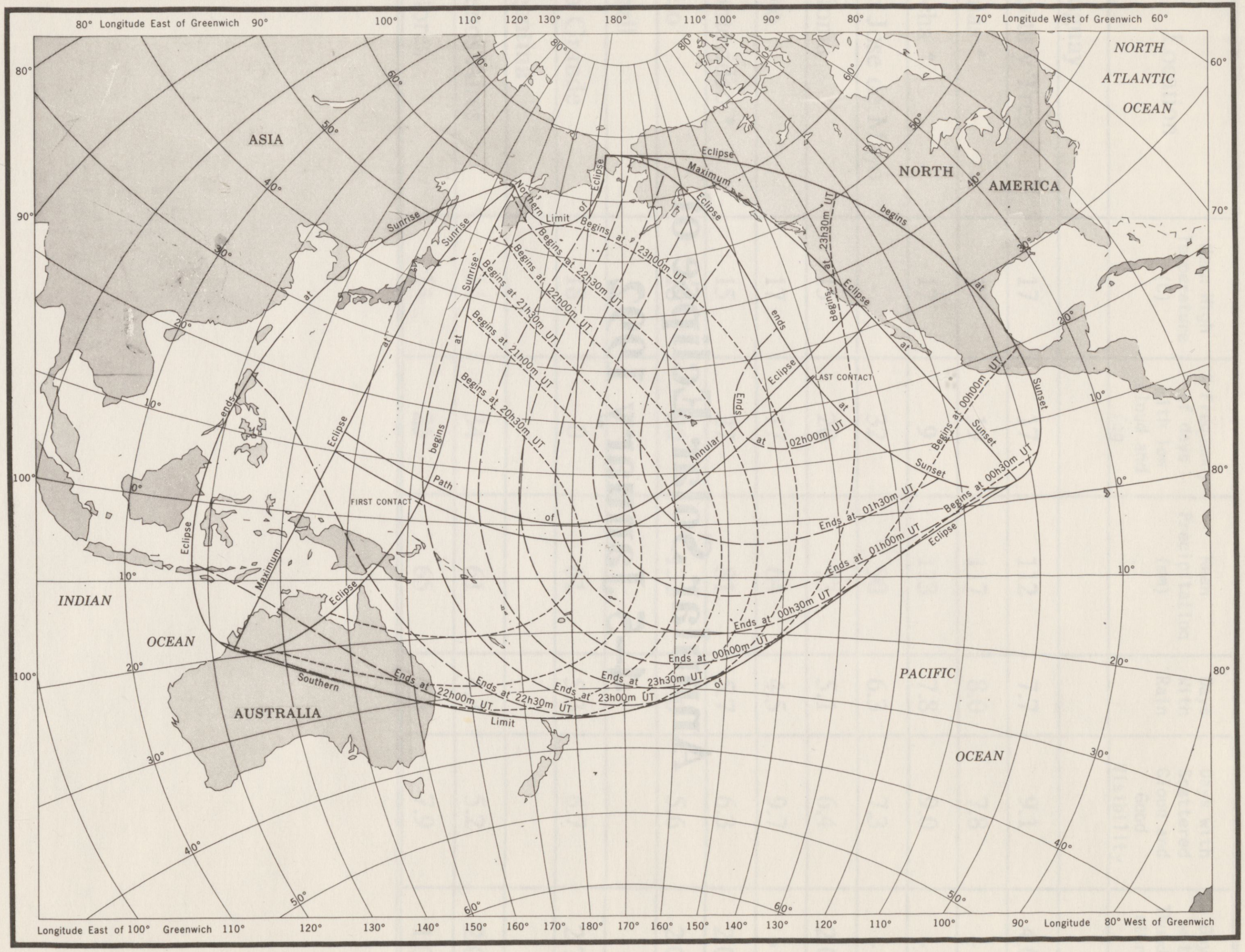
Location	Mean High Temperature (C)	% Frequency of low cloud and fog	Mean Rainfall (mm)	Days with Rain	Days with Scattered Cloud and Good Visibility	Days with Thunder-storms
Guam						
Agana Naval Air Station	29	7	108	8.5	0.2	0.1
Anderson Air Force Base	27	15	105	8.8	1.2	0.2
Caroline Islands						
Ulithi	29	19	60	13.3	-	0.0
Koror Island	30	6	321	15.6	0.2	1.4
Moen Flight Strip	29	6	243	11.0	0.1	1.3
Marshall Islands						
Kwajalein	29	2	81	7.0	2.7	0.0
Phoenix Islands						
Palmyra	29	7	337	14.5	0.0	-
Line Islands						
Christmas Island	29	1	26	2.4	5.7	0.0
Canton Airport	31	1	66	6.6	3.1	0.3
Hawaii						
Hilo, Hawaii	26	1	263	15.2	-	0.0
Kahului, Maui	27	3	103	5.2	8.3	0.7
Honolulu, Oahu	26	1	106	4.2	9.3	0.6
California						
San Nicholas Island	14	16	46	4.6	10.3	0.0
San Clemente Island	16	12	7	1.0	13.2	0.0
Los Angeles	18	15	64	5.5	10.7	0.4
Burbank	17	11	102	5.5	10.7	0.3
Long Beach	18	16	62	5.4	9.6	0.2
Point Mugu	17	13	79	5.1	10.8	0.4
San Diego County Airport	18	10	58	4.6	11.4	0.2
Imperial Beach	17	13	40	3.1	9.8	0.0
Oceanside	17	14	59	5.2	11.1	0.5

Table 2: June Climatological Statistics along the Eclipse Track.
(* indicates that the station is within the area of totality)

Location	Mean High Temperature (C)	% Frequency of days with low cloud and fog	Mean Precipitation (mm)	Days With Rain	Days with Scattered Cloud and Good Visibility	Days with Thunder-storms
Uruguay						
Trenta y Tres	17	17	112	7.7	9.1	4.0
Minas *	17	19	117	8.0	7.8	-
Rocha *	17	9	113	7.8	9.0	-
San Jose de Mayo	-	32	90	6.3	7.3	-
Colonia	15	20	73	5.1	6.4	2.0
Salto	17	17	64	4.5	9.7	-
Montevideo *	15	27	81	5.7	6.3	2.0
Melo	18	20	132	9.0	5.6	2.0
Brazil						
Rio Grande	18	0	61	5.3	6.7	2.7
Argentina						
Buenos Aires	14	34	61	4.3	5.2	2.0
Dolores	14	25	65	4.6	7.9	1.0

Annular Solar Eclipse of 4–5 January 1992

ANNULAR SOLAR ECLIPSE OF 4-5 JANUARY 1992


80° Longitude East of Greenwich 90°
100°
110° 120° 130°
180°
110° 100° 90° 80°
70° Longitude West of Greenwich 60°
ASIA
NORTH AMERICA
NORTH ATLANTIC OCEAN
INDIAN OCEAN
PACIFIC OCEAN
AUSTRALIA
Sunrise
Northern Limit of Eclipse
Eclipse Maximum
Eclipse begins at Sunrise
Begins at 23h00m UT
Begins at 22h30m UT
Begins at 22h00m UT
Begins at 21h30m UT
Begins at 21h00m UT
Begins at 20h30m UT
Begins at 23h30m UT
Eclipse ends at Sunrise
Eclipse begins at Sunset
Eclipse ends at Sunset
FIRST CONTACT
LAST CONTACT
Path of Annular Eclipse
Annular Eclipse Ends at 02h00m UT
Begins at 00h00m UT
Begins at 00h30m UT
Ends at 01h30m UT
Ends at 01h00m UT
Ends at 00h30m UT
Ends at 00h00m UT
Ends at 23h30m UT
Ends at 23h00m UT
Ends at 22h30m UT
Ends at 22h00m UT
Southern Limit of Eclipse
Longitude East of 100° Greenwich 110°
120° 130° 140° 150° 160° 170° 180° 170° 160° 150° 140° 130° 120° 110° 100°
90° Longitude 80° West of Greenwich

SURFACE PATH OF THE ANNULAR PHASE

U.T.	Northern Limit		Central Line		Southern Limit	
	Latitude	Longitude	Latitude	Longitude	Latitude	Longitude
	° ′	° ′	° ′	° ′	° ′	° ′
Limits	+13 10.4	+137 37.2	+11 32.6	+137 07.5	+ 9 56.1	+136 37.0
h m						
21 16	.. .. .	... .. .	. .. .	... .. .	+ 7 36.4	+142 13.5
21 18	+10 18.4	+144 20.0	+ 7 48.3	+146 02.7	+ 5 37.2	+147 05.6
21 20	+ 8 31.5	+148 35.7	+ 6 23.2	+149 31.6	+ 4 23.9	+150 10.1
21 25	+ 6 04.5	+154 43.2	+ 4 11.4	+155 10.4	+ 2 22.7	+155 30.0
21 30	+ 4 32.8	+158 50.4	+ 2 45.4	+159 08.9	+ 1 01.2	+159 22.5
21 35	+ 3 26.3	+162 05.2	+ 1 42.2	+162 20.1	+ 0 00.8	+162 31.3
21 40	+ 2 35.7	+164 49.1	+ 0 53.7	+165 02.5	− 0 45.9	+165 12.9
21 45	+ 1 56.2	+167 12.2	+ 0 15.9	+167 25.1	− 1 22.3	+167 35.6
21 50	+ 1 25.3	+169 20.1	− 0 13.7	+169 33.2	− 1 50.7	+169 44.3
21 55	+ 1 01.5	+171 16.4	− 0 36.4	+171 30.1	− 2 12.5	+171 42.1
22 00	+ 0 43.5	+173 03.5	− 0 53.5	+173 18.0	− 2 28.7	+173 31.2
22 05	+ 0 30.6	+174 43.1	− 1 05.5	+174 58.7	− 2 39.9	+175 13.2
22 10	+ 0 22.2	+176 16.6	− 1 13.1	+176 33.4	− 2 46.7	+176 49.3
22 15	+ 0 17.8	+177 44.9	− 1 16.6	+178 03.0	− 2 49.5	+178 20.3
22 20	+ 0 17.2	+179 08.9	− 1 16.5	+179 28.3	− 2 48.6	+179 47.2
22 25	+ 0 20.0	−179 30.8	− 1 13.0	−179 10.0	− 2 44.3	−178 49.7
22 30	+ 0 26.0	−178 13.6	− 1 06.2	−177 51.4	− 2 36.8	−177 29.6
22 35	+ 0 35.0	−176 59.1	− 0 56.4	−176 35.6	− 2 26.2	−176 12.2
22 40	+ 0 46.9	−175 46.9	− 0 43.7	−175 21.9	− 2 12.7	−174 57.1
22 45	+ 1 01.7	−174 36.5	− 0 28.2	−174 10.2	− 1 56.4	−173 43.9
22 50	+ 1 19.1	−173 27.8	− 0 09.9	−173 00.1	− 1 37.4	−172 32.4
22 55	+ 1 39.3	−172 20.2	+ 0 11.0	−171 51.3	− 1 15.7	−171 22.2
23 00	+ 2 02.0	−171 13.6	+ 0 34.5	−170 43.5	− 0 51.3	−170 13.1
23 05	+ 2 27.4	−170 07.7	+ 1 00.6	−169 36.4	− 0 24.4	−169 04.8
23 10	+ 2 55.3	−169 02.2	+ 1 29.4	−168 29.7	+ 0 05.1	−167 56.9
23 15	+ 3 26.0	−167 56.8	+ 2 00.7	−167 23.3	+ 0 37.2	−166 49.4
23 20	+ 3 59.3	−166 51.2	+ 2 34.7	−166 16.7	+ 1 11.8	−165 41.7
23 25	+ 4 35.3	−165 45.2	+ 3 11.4	−165 09.7	+ 1 49.1	−164 33.8
23 30	+ 5 14.2	−164 38.3	+ 3 50.8	−164 02.0	+ 2 29.2	−163 25.2
23 35	+ 5 56.0	−163 30.3	+ 4 33.1	−162 53.2	+ 3 12.0	−162 15.6
23 40	+ 6 40.9	−162 20.8	+ 5 18.4	−161 43.0	+ 3 57.7	−161 04.6
23 45	+ 7 29.0	−161 09.2	+ 6 06.8	−160 30.9	+ 4 46.4	−159 51.8
23 50	+ 8 20.6	−159 55.2	+ 6 58.6	−159 16.3	+ 5 38.4	−158 36.7
23 55	+ 9 15.9	−158 38.1	+ 7 53.9	−157 58.8	+ 6 33.8	−157 18.8
0 00	+10 15.2	−157 17.1	+ 8 53.2	−156 37.6	+ 7 33.0	−155 57.2
0 05	+11 19.1	−155 51.4	+ 9 56.7	−155 11.8	+ 8 36.3	−154 31.2
0 10	+12 28.0	−154 19.8	+11 05.1	−153 40.4	+ 9 44.2	−152 59.7
0 15	+13 42.7	−152 40.9	+12 18.9	−152 01.8	+10 57.4	−151 21.4
0 20	+15 04.1	−150 52.6	+13 39.2	−150 14.2	+12 16.6	−149 34.3
0 25	+16 33.7	−148 52.1	+15 07.1	−148 15.0	+13 43.1	−147 36.0
0 30	+18 13.5	−146 35.1	+16 44.6	−146 00.1	+15 18.6	−145 22.7
0 35	+20 07.0	−143 54.9	+18 34.7	−143 23.3	+17 05.9	−142 48.6
0 40	+22 20.1	−140 38.7	+20 42.6	−140 13.4	+19 09.5	−139 43.5
0 45	+25 06.2	−136 18.5	+23 19.5	−136 06.4	+21 38.9	−135 46.6
0 46	+25 46.0	−135 13.2	+23 56.3	−135 05.7	+22 13.6	−134 49.2
0 48	+27 16.6	−132 39.5	+25 18.8	−132 45.8	+23 30.2	−132 38.9
0 50	+29 12.9	−129 11.5	+26 59.7	−129 46.4	+25 01.2	−129 57.2
0 51	+30 32.0	−126 41.9	+28 02.5	−127 49.4	+25 55.4	−128 16.7
0 52	+32 41.5	−122 21.2	+29 22.8	−125 13.6	+26 59.9	−126 13.0
0 53	.. .. .	... .. .	+31 45.1	−120 17.1	+28 24.8	−123 22.7
Limits	+34 27.6	−118 30.9	+32 53.2	−117 45.0	+31 19.6	−117 00.1

For duration, path width, and altitude and azimuth of the Sun,
please see page 18, **Local Circumstances for Points on the Central Line**

ELEMENTS OF THE ECLIPSE

U.T. of geocentric conjunction in right ascension, January $4^{d}\ 23^{h}\ 14^{m}\ 42^{s}.825$

Julian Date = 2448626.4685512127

	h m s		s s
R.A. of Sun and Moon	19 00 11.850	Hourly motions	10.995 and 126.011
ΔT	58.577		
	° ′ ″		′ ″
Declination of Sun	−22 43 10.39	Hourly motion	+ 0 15.80
Declination of Moon	−22 20 39.75	Hourly motion	+ 5 46.57
Equatorial hor. par. of Sun	8.94	True semidiameter of Sun	16 15.9
Equatorial hor. par. of Moon	54 02.75	True semidiameter of Moon	14 43.6
Lunar figure offset, long.	+ 0.54		
Lunar figure offset, lat.	− 0.28		

CIRCUMSTANCES OF THE ECLIPSE

		U.T.	Longitude	Latitude
		d h m	° ′	° ′
Eclipse begins	January	4 20 03.6	+151 38.3	+ 3 08.6
Central eclipse begins		4 21 16.0	+137 07.5	+11 32.6
Central eclipse at local apparent noon		4 23 14.7	−167 27.1	+ 1 58.8
Central eclipse ends		5 0 53.1	−117 45.0	+32 53.2
Eclipse ends		5 2 05.6	−131 16.2	+24 42.5

Longitudes are measured positive east of Greenwich

BESSELIAN ELEMENTS, POLYNOMIAL FORM

The equations below represent simple least–squares fits to the tabular Besselian Elements.

Let $t = (\text{U.T.} - 19^{h})$ in units of hours; if t is negative, add 24^{h}.

These equations are valid over the range $0^{h}.967 \le t \le 7^{h}.258$. Do not use t outside the given range, and do not omit any terms in the series.

$$\begin{aligned}
x &= -2.09507528 + 0.49346258\,t + 0.00003512\,t^2 - 0.00000548\,t^3\\
y &= -0.01426910 + 0.10114617\,t + 0.00014715\,t^2 - 0.00000126\,t^3\\
\sin d &= -0.38651834 + 0.00006572\,t + 0.00000010\,t^2\\
\cos d &= 0.92228173 + 0.00002755\,t + 0.00000004\,t^2\\
\mu &= 103.78743352 + 14.99657269\,t + 0.00000152\,t^2 - 0.00000001\,t^3\\
\text{Radius penumbra} &= 0.57476043 + 0.00011111\,t - 0.00000991\,t^2\\
\text{Radius umbra} &= 0.02823329 + 0.00011048\,t - 0.00000984\,t^2
\end{aligned}$$

BESSELIAN ELEMENTS

U.T.	Intersection of Axis of Shadow with Fundamental Plane		Direction of Axis of Shadow			Radius of Shadow on Fundamental Plane	
	x	*y*	sin *d*	cos *d*	μ	Penumbra	Umbra
h m					°		
19 40	−1.766086	+0.053227	−0.386474	0.922300	113.78515	0.574830	+0.028303
19 50	−1.683835	+0.070121	−0.386464	0.922305	116.28458	0.574846	+0.028318
20 00	−1.601583	+0.087023	−0.386453	0.922309	118.78401	0.574862	+0.028334
20 10	−1.519330	+0.103933	−0.386442	0.922314	121.28344	0.574877	+0.028349
20 20	−1.437076	+0.120851	−0.386431	0.922319	123.78287	0.574891	+0.028363
20 30	−1.354821	+0.137777	−0.386420	0.922323	126.28230	0.574905	+0.028377
20 40	−1.272565	+0.154711	−0.386409	0.922328	128.78173	0.574918	+0.028390
20 50	−1.190310	+0.171652	−0.386398	0.922332	131.28116	0.574931	+0.028403
21 00	−1.108053	+0.188602	−0.386387	0.922337	133.78058	0.574943	+0.028415
21 10	−1.025797	+0.205559	−0.386375	0.922342	136.28001	0.574955	+0.028426
21 20	−0.943541	+0.222524	−0.386364	0.922346	138.77944	0.574966	+0.028437
21 30	−0.861285	+0.239496	−0.386353	0.922351	141.27887	0.574976	+0.028448
21 40	−0.779029	+0.256476	−0.386342	0.922355	143.77830	0.574986	+0.028458
21 50	−0.696774	+0.273464	−0.386331	0.922360	146.27773	0.574996	+0.028467
22 00	−0.614519	+0.290460	−0.386320	0.922365	148.77716	0.575005	+0.028476
22 10	−0.532266	+0.307463	−0.386309	0.922369	151.27660	0.575013	+0.028484
22 20	−0.450013	+0.324473	−0.386298	0.922374	153.77603	0.575021	+0.028492
22 30	−0.367761	+0.341491	−0.386287	0.922379	156.27546	0.575028	+0.028499
22 40	−0.285511	+0.358516	−0.386276	0.922383	158.77489	0.575035	+0.028506
22 50	−0.203261	+0.375549	−0.386265	0.922388	161.27432	0.575041	+0.028512
23 00	−0.121014	+0.392589	−0.386254	0.922393	163.77375	0.575046	+0.028518
23 10	−0.038768	+0.409637	−0.386243	0.922397	166.27318	0.575051	+0.028523
23 20	+0.043476	+0.426691	−0.386232	0.922402	168.77261	0.575056	+0.028527
23 30	+0.125718	+0.443753	−0.386221	0.922406	171.27204	0.575060	+0.028531
23 40	+0.207958	+0.460823	−0.386209	0.922411	173.77147	0.575063	+0.028534
23 50	+0.290195	+0.477899	−0.386198	0.922416	176.27090	0.575066	+0.028537
0 00	+0.372430	+0.494983	−0.386187	0.922420	178.77033	0.575068	+0.028539
0 10	+0.454663	+0.512073	−0.386176	0.922425	181.26976	0.575070	+0.028541
0 20	+0.536893	+0.529171	−0.386165	0.922430	183.76920	0.575071	+0.028542
0 30	+0.619119	+0.546276	−0.386154	0.922434	186.26863	0.575072	+0.028543
0 40	+0.701343	+0.563388	−0.386143	0.922439	188.76806	0.575072	+0.028543
0 50	+0.783563	+0.580507	−0.386132	0.922444	191.26749	0.575071	+0.028542
1 00	+0.865780	+0.597633	−0.386120	0.922448	193.76692	0.575070	+0.028541
1 10	+0.947994	+0.614765	−0.386109	0.922453	196.26635	0.575069	+0.028540
1 20	+1.030204	+0.631905	−0.386098	0.922458	198.76578	0.575067	+0.028538
1 30	+1.112410	+0.649051	−0.386087	0.922462	201.26522	0.575064	+0.028535
1 40	+1.194612	+0.666205	−0.386076	0.922467	203.76465	0.575061	+0.028532
1 50	+1.276810	+0.683365	−0.386065	0.922472	206.26408	0.575057	+0.028528
2 00	+1.359003	+0.700531	−0.386053	0.922476	208.76351	0.575052	+0.028524
2 10	+1.441192	+0.717705	−0.386042	0.922481	211.26294	0.575048	+0.028519
2 20	+1.523377	+0.734885	−0.386031	0.922486	213.76238	0.575042	+0.028514
2 30	+1.605557	+0.752072	−0.386020	0.922491	216.26181	0.575036	+0.028508

$\tan f_1$	0.004756
$\tan f_2$	0.004733
μ'	0.261740 radians per hour
d'	+0.000072 radians per hour

LOCAL CIRCUMSTANCES FOR POINTS ON THE CENTRAL LINE

Maximum Eclipse							Central Line		First Contact		
U.T.	Duration	Path Width	Obscur.	Mag.	Sun's Alt.	Sun's Az.	Longitude	Latitude	U.T.	*P*	*V*
h m	m s	km	%		°	°	° ′	° ′	h m s	°	°
21 18	7 43.0	362	82.5	0.954	10	115	+146 02.7	+ 7 48.2	.. ..	...	...
21 20	7 56.8	358	82.7	0.955	14	115	+149 31.5	+ 6 23.2	.. ..	...	...
21 25	8 22.9	353	83.0	0.955	21	116	+155 10.3	+ 4 11.3	20 04 03.7	269	354
21 30	8 44.4	349	83.2	0.956	27	117	+159 08.8	+ 2 45.3	20 05 01.9	269	353
21 35	9 03.6	347	83.4	0.957	31	118	+162 20.0	+ 1 42.2	20 06 25.1	269	352
21 40	9 21.3	346	83.5	0.957	35	119	+165 02.4	+ 0 53.7	20 08 03.5	268	351
21 45	9 37.8	345	83.6	0.957	38	120	+167 25.1	+ 0 15.8	20 09 52.7	268	350
21 50	9 53.2	344	83.8	0.958	42	121	+169 33.1	− 0 13.6	20 11 50.2	267	349
21 55	10 07.6	344	83.9	0.958	44	122	+171 30.0	− 0 36.4	20 13 54.5	266	347
22 00	10 21.1	344	83.9	0.958	47	123	+173 18.0	− 0 53.4	20 16 04.9	266	346
22 05	10 33.6	344	84.0	0.958	50	125	+174 58.7	− 1 05.5	20 18 20.8	265	345
22 10	10 45.0	344	84.1	0.958	52	127	+176 33.4	− 1 13.0	20 20 42.0	265	343
22 15	10 55.4	344	84.1	0.959	54	129	+178 03.0	− 1 16.6	20 23 08.5	264	341
22 20	11 04.7	344	84.2	0.959	56	132	+179 28.3	− 1 16.5	20 25 40.5	263	339
22 25	11 12.8	344	84.2	0.959	58	134	−179 09.9	− 1 12.9	20 28 18.1	262	338
22 30	11 19.8	344	84.3	0.959	60	137	−177 51.4	− 1 06.2	20 31 01.7	262	336
22 35	11 25.5	343	84.3	0.959	61	141	−176 35.5	− 0 56.4	20 33 51.7	261	333
22 40	11 30.0	343	84.3	0.959	63	145	−175 21.9	− 0 43.7	20 36 48.6	260	331
22 45	11 33.3	342	84.4	0.959	64	149	−174 10.2	− 0 28.1	20 39 53.0	259	329
22 50	11 35.3	341	84.4	0.959	65	154	−173 00.1	− 0 09.9	20 43 05.6	258	326
22 55	11 36.1	340	84.4	0.959	65	159	−171 51.3	+ 0 10.9	20 46 27.1	257	323
23 00	11 35.7	338	84.4	0.959	66	164	−170 43.4	+ 0 34.4	20 49 58.3	256	320
23 05	11 34.2	337	84.4	0.959	66	170	−169 36.3	+ 1 00.6	20 53 40.1	255	317
23 10	11 31.5	336	84.4	0.959	66	175	−168 29.7	+ 1 29.3	20 57 33.3	254	314
23 15	11 27.8	334	84.4	0.959	65	180	−167 23.2	+ 2 00.7	21 01 39.0	253	310
23 20	11 23.1	333	84.4	0.959	65	185	−166 16.7	+ 2 34.6	21 05 58.1	252	306
23 25	11 17.4	332	84.3	0.959	64	190	−165 09.7	+ 3 11.3	21 10 31.8	251	302
23 30	11 10.8	330	84.3	0.959	63	195	−164 02.0	+ 3 50.8	21 15 21.0	250	298
23 35	11 03.4	329	84.3	0.959	61	199	−162 53.2	+ 4 33.1	21 20 26.8	249	293
23 40	10 55.3	328	84.2	0.959	60	202	−161 43.0	+ 5 18.3	21 25 50.1	248	288
23 45	10 46.5	328	84.2	0.959	58	206	−160 30.8	+ 6 06.8	21 31 32.0	247	282
23 50	10 37.0	327	84.2	0.959	56	209	−159 16.3	+ 6 58.5	21 37 33.2	247	276
23 55	10 26.9	327	84.1	0.959	54	212	−157 58.8	+ 7 53.9	21 43 54.5	246	270
0 00	10 16.3	327	84.0	0.958	52	214	−156 37.6	+ 8 53.1	21 50 36.4	245	264
0 05	10 05.1	328	84.0	0.958	49	216	−155 11.8	+ 9 56.7	21 57 39.4	244	257
0 10	9 53.4	329	83.9	0.958	47	219	−153 40.3	+11 05.0	22 05 03.9	243	250
0 15	9 41.2	330	83.8	0.958	44	221	−152 01.8	+12 18.9	22 12 50.1	243	243
0 20	9 28.5	331	83.7	0.957	41	222	−150 14.2	+13 39.1	22 20 58.5	242	236
0 25	9 15.1	333	83.6	0.957	38	224	−148 14.9	+15 07.1	22 29 29.6	242	230
0 30	9 01.1	336	83.4	0.957	34	226	−146 00.0	+16 44.6	22 38 25.0	242	224
0 35	8 46.1	339	83.3	0.956	30	228	−143 23.2	+18 34.7	22 47 47.4	242	218
0 40	8 29.9	343	83.1	0.956	26	230	−140 13.3	+20 42.6	22 57 43.2	242	213
0 45	8 11.5	349	82.9	0.955	20	233	−136 06.4	+23 19.4	23 08 27.6	243	208
0 46	8 07.4	350	82.8	0.955	19	233	−135 05.7	+23 56.3	23 10 45.4	243	207
0 48	7 58.5	353	82.7	0.955	16	234	−132 45.8	+25 18.8	23 15 34.7	243	206
0 50	7 48.2	357	82.5	0.954	13	236	−129 46.4	+26 59.6	23 20 52.8	244	204
0 51	7 42.0	360	82.4	0.954	10	237	−127 49.4	+28 02.5	23 23 51.4	244	203
0 52	7 34.4	364	82.3	0.954	8	239	−125 13.6	+29 22.7	23 27 17.6	244	202
0 53	7 21.6	370	82.1	0.953	2	241	−120 17.1	+31 45.1	23 32 23.1	245	201

LOCAL CIRCUMSTANCES FOR POINTS ON THE CENTRAL LINE

U.T. at Maximum	Second Contact			Third Contact			Fourth Contact		
	U.T.	*P*	*V*	U.T.	*P*	*V*	U.T.	*P*	*V*
h m	h m s	°	°	h m s	°	°	h m s	°	°
21 18	21 14 09.1	269	347	21 21 52.1	89	166	22 47 48.8	88	154
21 20	21 16 02.2	269	346	21 23 59.1	89	165	22 54 14.5	88	152
21 25	21 20 49.3	268	345	21 29 12.3	88	163	23 07 25.9	86	146
21 30	21 25 38.6	268	343	21 34 23.1	88	161	23 18 51.9	84	140
21 35	21 30 29.1	267	341	21 39 32.8	87	159	23 29 16.1	83	133
21 40	21 35 20.3	266	339	21 44 41.7	86	157	23 38 52.0	81	126
21 45	21 40 12.2	265	336	21 49 50.0	85	154	23 47 45.9	80	118
21 50	21 45 04.5	264	334	21 54 57.7	84	152	23 56 01.3	78	109
21 55	21 49 57.3	263	331	22 00 05.0	83	149	0 03 41.3	77	99
22 00	21 54 50.5	262	328	22 05 11.7	82	145	0 10 48.6	75	89
22 05	21 59 44.3	261	325	22 10 17.9	81	142	0 17 25.9	74	79
22 10	22 04 38.5	260	321	22 15 23.6	80	138	0 23 35.9	73	69
22 15	22 09 33.2	259	318	22 20 28.7	79	134	0 29 21.4	72	60
22 20	22 14 28.5	258	314	22 25 33.2	77	130	0 34 44.8	70	52
22 25	22 19 24.3	257	310	22 30 37.2	76	125	0 39 48.6	69	45
22 30	22 24 20.7	256	305	22 35 40.5	75	120	0 44 34.8	68	38
22 35	22 29 17.7	255	300	22 40 43.3	74	115	0 49 05.7	67	33
22 40	22 34 15.3	254	295	22 45 45.4	73	109	0 53 22.9	66	28
22 45	22 39 13.5	252	289	22 50 46.9	72	103	0 57 28.0	66	23
22 50	22 44 12.4	251	283	22 55 47.7	71	96	1 01 22.5	65	20
22 55	22 49 11.8	250	276	23 00 48.0	70	89	1 05 07.6	64	16
23 00	22 54 11.8	249	270	23 05 47.6	69	82	1 08 44.4	64	14
23 05	22 59 12.5	248	263	23 10 46.7	68	75	1 12 13.9	63	11
23 10	23 04 13.7	247	256	23 15 45.2	67	69	1 15 36.9	63	9
23 15	23 09 15.4	246	249	23 20 43.3	66	62	1 18 54.1	62	7
23 20	23 14 17.7	246	243	23 25 40.8	65	56	1 22 06.1	62	6
23 25	23 19 20.4	245	237	23 30 37.8	64	50	1 25 13.5	61	4
23 30	23 24 23.6	244	231	23 35 34.5	64	45	1 28 16.6	61	3
23 35	23 29 27.3	243	226	23 40 30.7	63	40	1 31 15.9	61	2
23 40	23 34 31.3	243	221	23 45 26.6	62	36	1 34 11.5	61	1
23 45	23 39 35.7	242	217	23 50 22.2	62	32	1 37 03.7	61	0
23 50	23 44 40.4	242	213	23 55 17.4	62	28	1 39 52.6	61	360
23 55	23 49 45.4	241	209	0 00 12.4	61	25	1 42 38.2	61	359
0 00	23 54 50.8	241	206	0 05 07.1	61	22	1 45 20.5	61	359
0 05	23 59 56.4	241	203	0 10 01.5	61	20	1 47 59.2	61	358
0 10	0 05 02.2	241	201	0 14 55.7	61	18	1 50 34.2	61	358
0 15	0 10 08.4	241	198	0 19 49.6	61	16	1 53 04.9	61	358
0 20	0 15 14.8	241	197	0 24 43.3	61	14	1 55 30.6	61	358
0 25	0 20 21.5	241	195	0 29 36.7	61	13	1 57 50.2	62	359
0 30	0 25 28.6	241	194	0 34 29.7	61	12	2 00 02.0	62	359
0 35	0 30 36.2	242	193	0 39 22.3	62	11	2 02 03.2	63	360
0 40	0 35 44.4	242	192	0 44 14.3	62	10	2 03 48.8	63	1
0 45	0 40 53.7	243	191	0 49 05.2	63	10	2 05 07.9	64	2
0 46	0 41 55.7	243	191	0 50 03.1	63	10	2 05 18.5	65	2
0 48	0 44 00.2	244	191	0 51 58.8	64	10	2 05 31.2	65	3
0 50	0 46 05.4	244	192	0 53 53.6	65	11	.. ..	...	...
0 51	0 47 08.5	245	192	0 54 50.6	65	11	.. ..	...	...
0 52	0 48 12.4	245	192	0 55 46.8	66	11	.. ..	...	...
0 53	0 49 18.8	246	193	0 56 40.5	67	12	.. ..	...	...

LOCAL CIRCUMSTANCES FOR GEOGRAPHIC LOCATIONS

Position		Name of Location	Duration of Annularity	Maximum Eclipse					
Latitude	Longitude			Path Width	U.T.	Obscur.	Mag.	Sun's	
								Alt.	Az.
° ′	° ′	***United States***	m s	km	h m s	%		°	°
+35 05.0	−106 38.0	Albuquerque, NM			.. ..	... .	. ...	...	...
+33 50.0	−117 56.0	Anaheim, CA	1 55.2	376	.. ..	... .	. ...	...	...
+61 10.0	−150 00.0	Anchorage, AK			0 02 20.8	5.7	0.135	3	207
+33 21.0	−118 20.0	Avalon, Santa Catalina Is., CA	4 54.0	374	0 52 47.5	82.5	0.924	0	242
+34 15.2	−116 54.9	Big Bear Lake, CA (Solar Obs.)			.. ..	... .	. ...	...	...
+39 45.0	−105 00.0	Denver, CO			.. ..	... .	. ...	...	...
+33 04.0	−117 17.0	Encinitas, CA	1 19.2	374	.. ..	... .	. ...	...	...
+64 50.0	−147 50.0	Fairbanks, AK			.. ..	... .	. ...	...	...
+35 11.0	−111 44.4	Flagstaff, AZ (USNO Sta.)			.. ..	... .	. ...	...	...
+36 41.0	−119 47.0	Fresno, CA			0 50 39.7	75.9	0.837	0	241
+20 42.4	−156 15.4	Haleakala, HI (Solar Obs.)			0 12 34.4	60.9	0.704	40	211
+19 42.0	−155 04.0	Hilo, Hawaii, HI			0 14 36.4	65.6	0.745	40	214
+21 19.0	−157 50.0	Honolulu, Oahu, HI			0 09 03.1	56.7	0.668	41	209
+58 18.0	−134 25.0	Juneau, AK			.. ..	... .	. ...	...	...
+31 57.8	−111 36.0	Kitt Peak, AZ (National Obs.)			.. ..	... .	. ...	...	...
+36 10.0	−115 10.0	Las Vegas, NV			.. ..	... .	. ...	...	...
+33 47.0	−118 15.0	Long Beach, CA	3 14.5	375	0 52 36.2	82.6	0.917	0	242
+34 07.1	−118 17.9	Los Angeles, CA (Griffith Obs.)	2 06.7	376	.. ..	... .	. ...	...	...
+34 02.0	−118 42.0	Malibu, CA	3 45.4	376	0 52 23.2	82.5	0.909	0	242
+33 53.0	−118 24.0	Manhattan Beach, CA	3 24.7	376	0 52 31.4	82.6	0.914	0	242
+19 49.6	−155 28.3	Mauna Kea, HI (Mauna Kea Obs.)			0 13 51.6	64.5	0.735	40	213
+37 20.6	−121 38.2	Mount Hamilton, CA (Lick Obs.)			0 49 45.5	71.9	0.802	1	240
+30 40.3	−104 01.3	Mount Locke, TX (McDonald Obs.)			.. ..	... .	. ...	...	...
+34 13.0	−118 03.6	Mount Wilson, CA (Hale Obs.)	0 53.1	376	.. ..	... .	. ...	...	...
+33 38.0	−117 55.0	Newport Beach, CA	2 28.7	375	.. ..	... .	. ...	...	...
+33 12.0	−117 23.0	Oceanside, CA	1 27.5	375	.. ..	... .	. ...	...	...
+34 11.0	−119 11.0	Oxnard, CA			0 52 12.1	82.1	0.902	1	242
+33 21.4	−116 51.8	Palomar Mtn., CA (Palomar Obs.)			.. ..	... .	. ...	...	...
+34 10.0	−118 09.0	Pasadena, CA	1 26.1	376	.. ..	... .	. ...	...	...
+33 30.0	−112 03.0	Phoenix, AZ			.. ..	... .	. ...	...	...
+45 32.0	−122 40.0	Portland, OR			.. ..	... .	. ...	...	...
+33 51.0	−118 24.0	Redondo Beach, CA	3 32.2	375	0 52 32.4	82.6	0.915	0	242
+38 33.0	−121 30.0	Sacramento, CA			0 48 57.6	68.8	0.775	1	240
+40 45.0	−111 55.0	Salt Lake City, UT			.. ..	... .	. ...	...	...
+31 28.0	−100 28.0	San Angelo, TX			.. ..	... .	. ...	...	...
+34 07.0	−117 18.0	San Bernadino, CA			.. ..	... .	. ...	...	...
+32 50.0	−118 30.0	San Clemente Is., CA	6 53.2	373	0 52 59.3	82.5	0.929	1	242
+32 45.0	−117 10.0	San Diego, CA	1 23.5	374	.. ..	... .	. ...	...	...
+34 17.0	−118 27.0	San Fernando, CA	1 44.6	376	0 52 18.9	82.4	0.906	0	242
+37 45.0	−122 27.0	San Francisco, CA			0 49 12.5	69.8	0.784	2	239
+33 14.0	−119 30.0	San Nicolas Is., CA	9 39.3	374	0 52 34.8	82.6	0.918	1	242
+33 44.0	−117 54.0	Santa Ana, CA	2 06.8	375	.. ..	... .	. ...	...	...
+34 25.0	−119 41.0	Santa Barbara, CA			0 51 57.8	81.3	0.892	1	241
+33 29.0	−119 02.0	Santa Barbara Is., CA	7 06.1	374	0 52 34.5	82.6	0.917	1	242
+34 00.0	−118 25.0	Santa Monica, CA	3 00.5	376	0 52 27.8	82.6	0.912	0	242
+47 35.0	−122 20.0	Seattle, WA			.. ..	... .	. ...	...	...
+34 16.0	−118 45.0	Simi Valley, CA	2 29.8	376	0 52 15.5	82.2	0.904	0	242
+47 40.0	−117 25.0	Spokane, WA			.. ..	... .	. ...	...	...
+32 47.2	−105 49.2	Sunspot, NM (Sac. Peak Solar Obs.)			.. ..	... .	. ...	...	...
+34 11.0	−118 52.0	Thousand Oaks, CA	3 20.1	376	0 52 16.5	82.3	0.904	0	242
+32 14.0	−110 56.9	Tucson, AZ (Steward Obs.)			.. ..	... .	. ...	...	...
+34 15.0	−119 18.0	Ventura, CA			0 52 08.5	81.9	0.899	1	242
+20 54.0	−156 30.0	Wailuku, Maui, HI			0 12 02.9	60.0	0.697	40	211

Assumed to be sea level, except observatories.

Names and spelling are not authoritative, nor do they imply any official recognition of status.

No correction for elevation, limb or refraction included.

LOCAL CIRCUMSTANCES FOR GEOGRAPHIC LOCATIONS

Position		First Contact			Second Contact			Third Contact			Fourth Contact		
Latitude	Longitude	U.T.	P	V	U.T.	P	V	U.T.	P	V	U.T.	P	V
° ′	° ′	h m s	°	°	h m s	°	°	h m s	°	°	h m s	°	°
+35 05.0	−106 38.0	23 40 32.4	251	202							.. ..	...	...
+33 50.0	−117 56.0	23 33 52.4	244	200	0 49 34.7	214	161	.. ..	...	...	.. ..	...	...
+61 10.0	−150 00.0	23 17 20.5	193	184							0 45 47.9	131	112
+33 21.0	−118 20.0	23 33 41.9	245	201	0 49 24.8	225	171				.. ..	...	...
+34 15.2	−116 54.9	23 34 35.3	245	200	.. ..	...	...				.. ..	...	...
+39 45.0	−105 00.0	23 38 06.4	245	200	.. ..	...	...				.. ..	...	...
+33 04.0	−117 17.0	23 34 41.5	246	201	0 49 29.8	248	194				.. ..	...	...
+64 50.0	−147 50.0	23 18 12.4	192	183							.. ..	...	...
+35 11.0	−111 44.4	23 37 46.5	247	201	.. ..	...	...				.. ..	...	...
+36 41.0	−119 47.0	23 31 30.2	239	199							.. ..	...	...
+20 42.4	−156 15.4	22 13 53.4	230	235							1 49 53.6	77	25
+19 42.0	−155 04.0	22 15 29.8	232	235							1 51 44.4	75	21
+21 19.0	−157 50.0	22 10 20.5	228	237							1 47 06.6	80	29
+58 18.0	−134 25.0	23 21 20.4	205	188							.. ..	...	...
+31 57.8	−111 36.0	23 39 38.0	252	202							.. ..	...	...
+36 10.0	−115 10.0	23 35 03.4	243	200							.. ..	...	...
+33 47.0	−118 15.0	23 33 37.4	244	200	0 49 39.0	211	158				.. ..	...	...
+34 07.1	−118 17.9	23 33 28.8	244	200	0 50 07.4	196	144				.. ..	...	...
+34 02.0	−118 42.0	23 33 09.7	244	200	0 50 18.1	192	139				.. ..	...	...
+33 53.0	−118 24.0	23 33 27.8	244	200	0 49 49.6	205	152				.. ..	...	...
+19 49.6	−155 28.3	22 14 33.4	231	235							1 51 14.8	75	22
+37 20.6	−121 38.2	23 29 53.8	237	198							.. ..	...	...
+30 40.3	−104 01.3	23 45 03.1	259	205							.. ..	...	...
+34 13.0	−118 03.6	23 33 40.4	244	200	0 50 08.7	197	144				.. ..	...	...
+33 38.0	−117 55.0	23 33 57.4	245	200	0 49 27.4	221	168				.. ..	...	...
+33 12.0	−117 23.0	23 34 33.5	246	201	0 49 25.6	242	189				.. ..	...	...
+34 11.0	−119 11.0	23 32 42.2	243	200							.. ..	...	...
+33 21.4	−116 51.8	23 34 57.9	246	201	.. ..	...	...				.. ..	...	...
+34 10.0	−118 09.0	23 33 34.7	244	200	0 50 05.0	197	145				.. ..	...	...
+33 30.0	−112 03.0	23 38 25.9	249	201	.. ..	...	...				.. ..	...	...
+45 32.0	−122 40.0	23 27 37.4	226	194							.. ..	...	...
+33 51.0	−118 24.0	23 33 28.5	244	200	0 49 47.2	206	153				.. ..	...	...
+38 33.0	−121 30.0	23 29 43.9	236	198							.. ..	...	...
+40 45.0	−111 55.0	23 34 47.9	240	198							.. ..	...	...
+31 28.0	−100 28.0	23 45 54.5	261	205							.. ..	...	...
+34 07.0	−117 18.0	23 34 17.4	245	200	.. ..	...	...				.. ..	...	...
+32 50.0	−118 30.0	23 33 43.5	245	201	0 49 22.6	238	185				.. ..	...	...
+32 45.0	−117 10.0	23 34 54.6	246	201	0 49 44.4	259	205				.. ..	...	...
+34 17.0	−118 27.0	23 33 17.5	243	200	0 50 40.7	184	131				.. ..	...	...
+37 45.0	−122 27.0	23 29 07.8	236	198							.. ..	...	...
+33 14.0	−119 30.0	23 32 42.3	244	201	0 49 37.1	210	158				.. ..	...	...
+33 44.0	−117 54.0	23 33 56.1	245	200	0 49 30.2	218	165				.. ..	...	...
+34 25.0	−119 41.0	23 32 12.3	242	200							.. ..	...	...
+33 29.0	−119 02.0	23 33 02.7	244	200	0 49 40.8	209	156				.. ..	...	...
+34 00.0	−118 25.0	23 33 24.7	244	200	0 50 00.1	199	147				.. ..	...	...
+47 35.0	−122 20.0	23 27 22.8	224	194							.. ..	...	...
+34 16.0	−118 45.0	23 33 02.7	243	200	0 51 10.0	174	122				.. ..	...	...
+47 40.0	−117 25.0	23 29 30.8	227	194							.. ..	...	...
+32 47.2	−105 49.2	23 42 34.4	255	203							.. ..	...	...
+34 11.0	−118 52.0	23 32 58.4	243	200	0 51 00.5	177	125				.. ..	...	...
+32 14.0	−110 56.9	23 39 53.7	252	202							.. ..	...	...
+34 15.0	−119 18.0	23 32 35.0	243	200							.. ..	...	...
+20 54.0	−156 30.0	22 13 30.0	229	235							1 49 24.2	78	26

Dot leaders indicate the phenomenon occurs below the horizon. Blanks indicate the phenomenon does not occur for the location.

LOCAL CIRCUMSTANCES FOR GEOGRAPHIC LOCATIONS

Position		Name of Location	Duration of Annularity	Maximum Eclipse					
Latitude	Longitude			Path Width	U.T.	Obscur.	Mag.	Sun's Alt.	Az.
° ′	° ′	***Other***	m s	km	h m s	%		°	°
−27 30.0	+153 00.0	Brisbane, Australia			21 33 44.4	2.7	0.081	32	101
+51 05.0	−114 05.0	Calgary, Canada			.. .. ..	... .	. ...	...	...
+28 40.0	−106 06.0	Chihuahua, Mexico			.. .. ..	... .	. ...	...	...
−12 23.0	+130 44.0	Darwin, Australia			21 15 40.7	14.3	0.253	3	113
+20 40.0	−103 20.0	Guadalajara, Mexico			.. .. ..	... .	. ...	...	...
+13 30.0	+144 45.0	Guam Island			21 19 52.6	74.2	0.822	7	115
+24 10.0	−110 17.0	La Paz, Baja Cal., Mexico			.. .. ..	... .	. ...	...	...
+14 37.0	+120 58.0	Manila, Philippines			.. .. ..	... .	. ...	...	...
+19 25.0	− 99 10.0	Mexico City, Mexico			.. .. ..	... .	. ...	...	...
+28 12.0	−177 24.0	Midway Island			23 05 58.4	20.1	0.320	38	166
+25 40.0	−100 20.0	Monterrey, Mexico			.. .. ..	... .	. ...	...	...
+49 07.0	−119 30.0	Mt. Kobau, Canada (Dominion Obs.)			.. .. ..	... .	. ...	...	...
+34 40.0	+135 30.0	Osaka, Japan			.. .. ..	... .	. ...	...	...
−14 16.0	−170 43.0	Pago Pago, American Samoa			22 42 25.1	45.3	0.567	76	130
+ 5 53.0	−162 03.0	Palmyra Is.	9 48.3	330	23 39 47.0	84.2	0.941	59	201
−17 32.0	−149 34.0	Papeete, Tahiti			23 34 42.7	11.7	0.220	68	253
− 9 30.0	+147 07.0	Port Moresby, Papua New Guinea			21 18 45.5	38.7	0.507	18	111
+19 03.0	− 98 10.0	Puebla, Mexico			.. .. ..	... .	. ...	...	...
+35 05.0	+129 02.0	Pusan, S. Korea			.. .. ..	... .	. ...	...	...
− 1 10.0	+174 45.0	Tabiteuea Is., Gilbert Is.	10 30.3	343	22 04 15.1	84.0	0.956	49	125
+32 29.0	−117 10.0	Tijuana, Mexico	1 46.9	373	.. .. ..	... .	. ...	...	...
+35 40.0	+139 45.0	Tokyo, Japan			.. .. ..	... .	. ...	...	...
+49 13.0	−123 06.0	Vancouver, Canada			.. .. ..	... .	. ...	...	...
+ 9 27.0	+138 04.0	Yap Is., Caroline Is.	2 35.1	368	21 15 20.8	82.1	0.909	2	113

Assumed to be sea level, except observatories.

Names and spelling are not authoritative, nor do they imply any official recognition of status.

No correction for elevation, limb or refraction included.

LOCAL CIRCUMSTANCES FOR GEOGRAPHIC LOCATIONS

Position		First Contact			Second Contact			Third Contact			Fourth Contact		
Latitude	Longitude	U.T.	*P*	*V*	U.T.	*P*	*V*	U.T.	*P*	*V*	U.T.	*P*	*V*
° ′	° ′	h m s	°	°	h m s	°	°	h m s	°	°	h m s	°	°
−27 30.0	+153 00.0	21 00 26.1	334	84							22 09 09.6	20	128
+51 05.0	−114 05.0	23 29 11.8	225	193							.. ..	...	...
+28 40.0	−106 06.0	23 45 26.1	261	205							.. ..	...	...
−12 23.0	+130 44.0	.. ..	...	...							22 04 53.7	42	140
+20 40.0	−103 20.0	23 54 45.2	276	211							.. ..	...	...
+13 30.0	+144 45.0	.. ..	...	...							22 47 39.3	96	157
+24 10.0	−110 17.0	23 45 45.3	265	207							.. ..	...	...
+14 37.0	+120 58.0	.. ..	...	...							22 27 18.2	84	158
+19 25.0	− 99 10.0	23 59 09.3	282	214							.. ..	...	...
+28 12.0	−177 24.0	21 32 01.6	215	251							0 41 55.6	110	97
+25 40.0	−100 20.0	23 51 20.4	270	209							.. ..	...	...
+49 07.0	−119 30.0	23 28 15.2	224	193							.. ..	...	...
+34 40.0	+135 30.0	.. ..	...	...							22 44 25.7	121	169
−14 16.0	−170 43.0	20 52 51.2	281	5							0 35 32.6	42	337
+ 5 53.0	−162 03.0	21 25 26.7	247	287	23 34 52.1	216	195	23 44 40.4	89	64	1 34 17.4	62	3
−17 32.0	−149 34.0	22 19 51.6	294	257							0 42 21.9	11	282
− 9 30.0	+147 07.0	20 12 52.4	298	37							22 36 56.3	60	145
+19 03.0	− 98 10.0	0 00 16.2	284	215							.. ..	...	...
+35 05.0	+129 02.0	.. ..	...	...							22 42 14.9	117	169
− 1 10.0	+174 45.0	20 18 00.5	265	345	21 59 01.0	265	329	22 09 31.4	77	139	0 16 25.7	74	81
+32 29.0	−117 10.0	23 35 00.8	247	201	0 50 00.2	267	213				.. ..	...	...
+35 40.0	+139 45.0	.. ..	...	...							22 47 05.2	124	170
+49 13.0	−123 06.0	23 26 40.6	222	193							.. ..	...	...
+ 9 27.0	+138 04.0	.. ..	...	...	21 14 02.9	339	58	21 16 38.0	20	99	22 36 27.4	86	157

Dot leaders indicate the phenomenon occurs below the horizon. Blanks indicate the phenomenon does not occur for the location.

SURFACE PATH OF THE ANNULAR PHASE OVER LAND

Longitude	Latitude of: Northern Limit	Latitude of: Central Line	Latitude of: Southern Limit	Universal Time at: Northern Limit	Universal Time at: Central Line	Universal Time at: Southern Limit	On Central Line: Maximum Duration	On Central Line: Path Width	On Central Line: Sun's Alt.	On Central Line: Sun's Az.
° ′	° ′	° ′	° ′	h m s	h m s	h m s	m s	km	°	°
+140 00	+12 09.1	. .. .	+ 8 31.7	21 17 03.2	.. ..	21 15 31.4	. .. .	...	.	...
+140 30	+11 56.3	. .. .	+ 8 19.2	21 17 08.3	.. ..	21 15 37.8	. .. .	...	.	...
+141 00	+11 43.5	. .. .	+ 8 06.8	21 17 13.4	.. ..	21 15 44.3	. .. .	...	.	...
+141 30	+11 30.7	. .. .	+ 7 54.4	21 17 18.5	.. ..	21 15 50.7	. .. .	...	.	...
+142 00	+11 17.9	+ 9 29.3	+ 7 42.0	21 17 23.6	21 16 35.9	21 15 57.2	7 28.8	366	5	114
+142 30	+11 05.1	+ 9 16.7	+ 7 29.6	21 17 28.7	21 16 44.0	21 16 04.6	7 30.5	366	6	114
+143 00	+10 52.3	+ 9 04.2	+ 7 17.2	21 17 35.4	21 16 52.1	21 16 13.6	7 32.2	365	6	114
+143 30	+10 39.6	+ 8 51.6	+ 7 04.9	21 17 43.6	21 17 00.2	21 16 23.6	7 33.8	365	7	114
+144 00	+10 26.9	+ 8 39.1	+ 6 52.6	21 17 53.1	21 17 10.1	21 16 34.5	7 35.6	364	8	114
+144 30	+10 14.2	+ 8 26.6	+ 6 40.3	21 18 03.5	21 17 20.9	21 16 46.0	7 37.3	364	8	115
+145 00	+10 01.5	+ 8 14.2	+ 6 28.1	21 18 14.4	21 17 32.8	21 16 58.5	7 39.1	363	9	115
+145 30	+ 9 48.9	+ 8 01.8	+ 6 15.9	21 18 26.3	21 17 45.3	21 17 11.8	7 41.0	363	9	115
+146 00	+ 9 36.3	+ 7 49.4	+ 6 03.7	21 18 39.1	21 17 58.8	21 17 26.0	7 42.8	362	10	115
+146 30	+ 9 23.7	+ 7 37.0	+ 5 51.6	21 18 52.7	21 18 13.2	21 17 41.0	7 44.7	361	11	115
+147 00	+ 9 11.2	+ 7 24.7	+ 5 39.5	21 19 07.3	21 18 28.5	21 17 57.0	7 46.6	361	11	115
+147 30	+ 8 58.7	+ 7 12.5	+ 5 27.4	21 19 22.8	21 18 44.6	21 18 13.9	7 48.6	360	12	115
+148 00	+ 8 46.3	+ 7 00.2	+ 5 15.4	21 19 39.2	21 19 01.8	21 18 31.7	7 50.6	360	12	115
+148 30	+ 8 33.9	+ 6 48.1	+ 5 03.5	21 19 56.6	21 19 19.9	21 18 50.5	7 52.6	359	13	115
+149 00	+ 8 21.5	+ 6 35.9	+ 4 51.6	21 20 15.0	21 19 39.0	21 19 10.2	7 54.6	359	14	115
+149 30	+ 8 09.2	+ 6 23.8	+ 4 39.7	21 20 34.4	21 19 59.0	21 19 30.9	7 56.7	358	14	115
+150 00	+ 7 57.0	+ 6 11.8	+ 4 27.9	21 20 54.8	21 20 20.1	21 19 52.5	7 58.8	358	15	115
+150 30	+ 7 44.8	+ 5 59.9	+ 4 16.2	21 21 16.2	21 20 42.1	21 20 15.2	8 01.0	357	15	116
+151 00	+ 7 32.6	+ 5 47.9	+ 4 04.5	21 21 38.6	21 21 05.2	21 20 38.9	8 03.2	357	16	116
+151 30	+ 7 20.6	+ 5 36.1	+ 3 52.9	21 22 02.2	21 21 29.3	21 21 03.6	8 05.4	356	17	116
+152 00	+ 7 08.6	+ 5 24.3	+ 3 41.3	21 22 26.7	21 21 54.5	21 21 29.4	8 07.7	356	17	116
+152 30	+ 6 56.6	+ 5 12.6	+ 3 29.9	21 22 52.4	21 22 20.8	21 21 56.2	8 10.0	355	18	116
+153 00	+ 6 44.8	+ 5 01.0	+ 3 18.5	21 23 19.2	21 22 48.2	21 22 24.1	8 12.3	355	19	116
+153 30	+ 6 33.0	+ 4 49.4	+ 3 07.1	21 23 47.1	21 23 16.6	21 22 53.1	8 14.7	354	19	116
+154 00	+ 6 21.3	+ 4 37.9	+ 2 55.9	21 24 16.2	21 23 46.2	21 23 23.1	8 17.1	354	20	116
+154 30	+ 6 09.6	+ 4 26.6	+ 2 44.7	21 24 46.4	21 24 16.9	21 23 54.3	8 19.6	353	20	116
+155 00	+ 5 58.1	+ 4 15.2	+ 2 33.7	21 25 17.8	21 24 48.8	21 24 26.6	8 22.1	353	21	116
+155 30	+ 5 46.6	+ 4 04.0	+ 2 22.7	21 25 50.4	21 25 21.9	21 25 00.1	8 24.6	352	22	116
+156 00	+ 5 35.3	+ 3 52.9	+ 2 11.8	21 26 24.2	21 25 56.1	21 25 34.8	8 27.2	352	22	117
+156 30	+ 5 24.0	+ 3 41.9	+ 2 01.0	21 26 59.2	21 26 31.6	21 26 10.6	8 29.8	351	23	117
+157 00	+ 5 12.9	+ 3 31.0	+ 1 50.4	21 27 35.5	21 27 08.2	21 26 47.6	8 32.5	351	24	117
+157 30	+ 5 01.8	+ 3 20.2	+ 1 39.8	21 28 13.1	21 27 46.1	21 27 25.8	8 35.2	351	24	117
+158 00	+ 4 50.9	+ 3 09.5	+ 1 29.3	21 28 51.9	21 28 25.3	21 28 05.2	8 38.0	350	25	117
+158 30	+ 4 40.1	+ 2 58.9	+ 1 19.0	21 29 32.1	21 29 05.7	21 28 45.9	8 40.8	350	26	117
+159 00	+ 4 29.4	+ 2 48.4	+ 1 08.8	21 30 13.5	21 29 47.5	21 29 27.8	8 43.6	349	26	117
+159 30	+ 4 18.8	+ 2 38.1	+ 0 58.7	21 30 56.4	21 30 30.5	21 30 11.0	8 46.5	349	27	117
+160 00	+ 4 08.4	+ 2 27.9	+ 0 48.8	21 31 40.5	21 31 14.9	21 30 55.5	8 49.4	349	28	117
+160 30	+ 3 58.1	+ 2 17.9	+ 0 38.9	21 32 26.1	21 32 00.6	21 31 41.3	8 52.4	348	28	117
+161 00	+ 3 47.9	+ 2 07.9	+ 0 29.3	21 33 13.1	21 32 47.7	21 32 28.4	8 55.4	348	29	118
+161 30	+ 3 37.9	+ 1 58.2	+ 0 19.8	21 34 01.5	21 33 36.1	21 33 16.9	8 58.5	348	30	118
+162 00	+ 3 28.0	+ 1 48.6	+ 0 10.4	21 34 51.3	21 34 25.9	21 34 06.7	9 01.6	347	31	118
+162 30	+ 3 18.3	+ 1 39.1	+ 0 01.2	21 35 42.6	21 35 17.2	21 34 57.8	9 04.7	347	31	118
+163 00	+ 3 08.8	+ 1 29.8	− 0 07.9	21 36 35.4	21 36 09.9	21 35 50.3	9 07.9	347	32	118
+163 30	+ 2 59.5	+ 1 20.7	− 0 16.8	21 37 29.6	21 37 04.0	21 36 44.3	9 11.1	346	33	118
+164 00	+ 2 50.3	+ 1 11.8	− 0 25.5	21 38 25.4	21 37 59.6	21 37 39.6	9 14.4	346	33	118
+164 30	+ 2 41.3	+ 1 03.0	− 0 34.0	21 39 22.7	21 38 56.6	21 38 36.4	9 17.7	346	34	119
+165 00	+ 2 32.5	+ 0 54.4	− 0 42.3	21 40 21.6	21 39 55.2	21 39 34.6	9 21.1	346	35	119
+165 30	+ 2 23.9	+ 0 46.1	− 0 50.5	21 41 22.1	21 40 55.3	21 40 34.2	9 24.4	345	36	119
+166 00	+ 2 15.5	+ 0 37.9	− 0 58.4	21 42 24.1	21 41 56.9	21 41 35.3	9 27.9	345	36	119
+166 30	+ 2 07.3	+ 0 29.9	− 1 06.1	21 43 27.8	21 43 00.0	21 42 37.9	9 31.3	345	37	119

SURFACE PATH OF THE ANNULAR PHASE OVER LAND

Longitude	Latitude of:			Universal Time at:			On Central Line			
	Northern Limit	Central Line	Southern Limit	Northern Limit	Central Line	Southern Limit	Maximum Duration	Path Width	Sun's Alt.	Az.
° ′	° ′	° ′	° ′	h m s	h m s	h m s	m s	km	°	°
+167 00	+ 1 59.3	+ 0 22.2	− 1 13.7	21 44 33.1	21 44 04.7	21 43 42.0	9 34.9	345	38	120
+167 30	+ 1 51.6	+ 0 14.7	− 1 20.9	21 45 40.0	21 45 11.0	21 44 47.6	9 38.4	345	38	120
+168 00	+ 1 44.1	+ 0 07.4	− 1 28.0	21 46 48.6	21 46 18.9	21 45 54.7	9 42.0	344	39	120
+168 30	+ 1 36.9	+ 0 00.3	− 1 34.8	21 47 58.9	21 47 28.4	21 47 03.3	9 45.6	344	40	120
+169 00	+ 1 29.9	− 0 06.5	− 1 41.4	21 49 10.9	21 48 39.5	21 48 13.5	9 49.2	344	41	121
+169 30	+ 1 23.1	− 0 13.0	− 1 47.8	21 50 24.6	21 49 52.3	21 49 25.3	9 52.9	344	41	121
+170 00	+ 1 16.6	− 0 19.3	− 1 53.9	21 51 40.1	21 51 06.7	21 50 38.6	9 56.5	344	42	121
+170 30	+ 1 10.5	− 0 25.3	− 1 59.7	21 52 57.3	21 52 22.7	21 51 53.5	10 00.2	344	43	121
+171 00	+ 1 04.6	− 0 31.0	− 2 05.2	21 54 16.2	21 53 40.5	21 53 10.0	10 03.9	344	44	122
+171 30	+ 0 58.9	− 0 36.4	− 2 10.5	21 55 37.0	21 54 59.9	21 54 28.1	10 07.7	344	44	122
+172 00	+ 0 53.6	− 0 41.6	− 2 15.4	21 56 59.5	21 56 21.0	21 55 47.8	10 11.4	344	45	122
+172 30	+ 0 48.7	− 0 46.4	− 2 20.1	21 58 23.8	21 57 43.9	21 57 09.1	10 15.2	344	46	123
+173 00	+ 0 44.0	− 0 50.9	− 2 24.5	21 59 50.0	21 59 08.4	21 58 32.0	10 18.9	344	47	123
+173 30	+ 0 39.7	− 0 55.1	− 2 28.5	22 01 18.0	22 00 34.7	21 59 56.6	10 22.6	344	47	124
+174 00	+ 0 35.7	− 0 59.0	− 2 32.2	22 02 47.8	22 02 02.7	22 01 22.8	10 26.4	344	48	124
+174 30	+ 0 32.1	− 1 02.5	− 2 35.6	22 04 19.4	22 03 32.5	22 02 50.7	10 30.1	344	49	125
+175 00	+ 0 28.8	− 1 05.6	− 2 38.7	22 05 52.9	22 05 04.0	22 04 20.2	10 33.8	344	50	125
+175 30	+ 0 25.9	− 1 08.4	− 2 41.3	22 07 28.3	22 06 37.3	22 05 51.3	10 37.5	344	50	126
+176 00	+ 0 23.4	− 1 10.8	− 2 43.7	22 09 05.5	22 08 12.3	22 07 24.1	10 41.1	344	51	126
+176 30	+ 0 21.3	− 1 12.9	− 2 45.6	22 10 44.6	22 09 49.0	22 08 58.6	10 44.7	344	52	127
+177 00	+ 0 19.6	− 1 14.5	− 2 47.2	22 12 25.5	22 11 27.5	22 10 34.7	10 48.2	344	53	128
+177 30	+ 0 18.3	− 1 15.8	− 2 48.4	22 14 08.2	22 13 07.8	22 12 12.4	10 51.7	344	53	128
+178 00	+ 0 17.5	− 1 16.6	− 2 49.2	22 15 52.8	22 14 49.7	22 13 51.8	10 55.1	344	54	129
+178 30	+ 0 17.1	− 1 17.0	− 2 49.6	22 17 39.3	22 16 33.5	22 15 32.8	10 58.5	344	55	130
+179 00	+ 0 17.1	− 1 17.0	− 2 49.6	22 19 27.5	22 18 18.9	22 17 15.5	11 01.8	344	56	131
+179 30	+ 0 17.6	− 1 16.5	− 2 49.1	22 21 17.6	22 20 06.1	22 18 59.7	11 04.9	344	56	132
+180 00	+ 0 18.6	− 1 15.6	− 2 48.2	22 23 09.4	22 21 54.9	22 20 45.6	11 08.0	344	57	133
−179 30	+ 0 20.0	− 1 14.2	− 2 46.9	22 25 03.1	22 23 45.4	22 22 33.1	11 11.0	344	58	134
−179 00	+ 0 22.0	− 1 12.3	− 2 45.1	22 26 58.4	22 25 37.6	22 24 22.1	11 13.8	344	58	135
−178 30	+ 0 24.4	− 1 10.0	− 2 42.8	22 28 55.5	22 27 31.4	22 26 12.7	11 16.6	344	59	136
−178 00	+ 0 27.4	− 1 07.1	− 2 40.1	22 30 54.2	22 29 26.8	22 28 04.9	11 19.1	344	60	137
−177 30	+ 0 30.9	− 1 03.8	− 2 36.9	22 32 54.6	22 31 23.8	22 29 58.5	11 21.6	344	60	138
−177 00	+ 0 34.9	− 0 59.9	− 2 33.2	22 34 56.5	22 33 22.4	22 31 53.6	11 23.9	343	61	140
−176 30	+ 0 39.4	− 0 55.6	− 2 29.0	22 37 00.0	22 35 22.4	22 33 50.2	11 26.0	343	62	141
−176 00	+ 0 44.5	− 0 50.7	− 2 24.3	22 39 05.0	22 37 23.9	22 35 48.2	11 27.9	343	62	143
−175 30	+ 0 50.2	− 0 45.3	− 2 19.1	22 41 11.5	22 39 26.8	22 37 47.6	11 29.7	343	63	144
−175 00	+ 0 56.4	− 0 39.3	− 2 13.3	22 43 19.3	22 41 31.1	22 39 48.3	11 31.2	342	63	146
−174 30	+ 1 03.2	− 0 32.8	− 2 07.1	22 45 28.4	22 43 36.7	22 41 50.4	11 32.6	342	64	148
−174 00	+ 1 10.6	− 0 25.7	− 2 00.3	22 47 38.7	22 45 43.5	22 43 53.6	11 33.7	342	64	150
−173 30	+ 1 18.5	− 0 18.1	− 1 53.0	22 49 50.2	22 47 51.5	22 45 58.1	11 34.7	341	64	152
−173 00	+ 1 27.0	− 0 09.9	− 1 45.1	22 52 02.8	22 50 00.6	22 48 03.7	11 35.4	341	65	154
−172 30	+ 1 36.2	− 0 01.2	− 1 36.7	22 54 16.4	22 52 10.8	22 50 10.4	11 35.9	340	65	156
−172 00	+ 1 45.9	+ 0 08.2	− 1 27.7	22 56 30.8	22 54 21.9	22 52 18.0	11 36.2	340	65	158
−171 30	+ 1 56.1	+ 0 18.0	− 1 18.2	22 58 46.0	22 56 33.9	22 54 26.7	11 36.2	339	66	161
−171 00	+ 2 07.0	+ 0 28.5	− 1 08.2	23 01 02.0	22 58 46.7	22 56 36.2	11 36.0	339	66	163
−170 30	+ 2 18.5	+ 0 39.5	− 0 57.6	23 03 18.4	23 01 00.2	22 58 46.4	11 35.6	338	66	165
−170 00	+ 2 30.5	+ 0 51.1	− 0 46.4	23 05 35.4	23 03 14.2	23 00 57.4	11 34.9	338	66	168
−169 30	+ 2 43.1	+ 1 03.3	− 0 34.7	23 07 52.7	23 05 28.8	23 03 09.0	11 34.0	337	66	170
−169 00	+ 2 56.3	+ 1 16.0	− 0 22.4	23 10 10.2	23 07 43.7	23 05 21.1	11 32.9	336	66	173
−168 30	+ 3 10.1	+ 1 29.2	− 0 09.6	23 12 27.8	23 09 58.9	23 07 33.7	11 31.6	336	66	175
−168 00	+ 3 24.4	+ 1 43.1	+ 0 03.7	23 14 45.4	23 12 14.3	23 09 46.5	11 30.0	335	66	177
−167 30	+ 3 39.3	+ 1 57.4	+ 0 17.5	23 17 02.8	23 14 29.7	23 11 59.6	11 28.3	334	65	180
−167 00	+ 3 54.7	+ 2 12.3	+ 0 31.9	23 19 20.0	23 16 45.1	23 14 12.8	11 26.3	334	65	182
−166 30	+ 4 10.6	+ 2 27.7	+ 0 46.8	23 21 36.7	23 19 00.3	23 16 26.0	11 24.1	333	65	184

SURFACE PATH OF THE ANNULAR PHASE OVER LAND

Longitude	Latitude of:			Universal Time at:			On Central Line			
	Northern Limit	Central Line	Southern Limit	Northern Limit	Central Line	Southern Limit	Maximum Duration	Path Width	Sun's Alt.	Az.
° ′	° ′	° ′	° ′	h m s	h m s	h m s	m s	km	°	°
−166 00	+ 4 27.0	+ 2 43.6	+ 1 02.2	23 23 53.0	23 21 15.1	23 18 39.1	11 21.8	333	64	187
−165 30	+ 4 43.9	+ 3 00.0	+ 1 18.1	23 26 08.5	23 23 29.5	23 20 52.0	11 19.2	332	64	189
−165 00	+ 5 01.3	+ 3 16.9	+ 1 34.5	23 28 23.2	23 25 43.4	23 23 04.6	11 16.5	331	64	191
−164 30	+ 5 19.2	+ 3 34.2	+ 1 51.3	23 30 37.0	23 27 56.6	23 25 16.7	11 13.7	331	63	193
−164 00	+ 5 37.5	+ 3 52.0	+ 2 08.6	23 32 49.8	23 30 08.9	23 27 28.2	11 10.7	330	62	195
−163 30	+ 5 56.2	+ 4 10.2	+ 2 26.3	23 35 01.4	23 32 20.4	23 29 39.1	11 07.5	330	62	197
−163 00	+ 6 15.3	+ 4 28.8	+ 2 44.4	23 37 11.7	23 34 30.8	23 31 49.2	11 04.2	329	61	198
−162 30	+ 6 34.8	+ 4 47.9	+ 3 02.9	23 39 20.6	23 36 40.1	23 33 58.3	11 00.9	329	61	200
−162 00	+ 6 54.6	+ 5 07.2	+ 3 21.8	23 41 28.1	23 38 48.1	23 36 06.5	10 57.4	329	60	202
−161 30	+ 7 14.8	+ 5 27.0	+ 3 41.1	23 43 33.9	23 40 54.8	23 38 13.5	10 53.8	328	59	203
−161 00	+ 7 35.3	+ 5 47.0	+ 4 00.7	23 45 38.1	23 43 00.0	23 40 19.3	10 50.1	328	59	204
−160 30	+ 7 56.1	+ 6 07.4	+ 4 20.6	23 47 40.4	23 45 03.7	23 42 23.7	10 46.4	328	58	206
−160 00	+ 8 17.2	+ 6 28.1	+ 4 40.9	23 49 41.0	23 47 05.7	23 44 26.8	10 42.6	328	57	207
−159 30	+ 8 38.5	+ 6 49.0	+ 5 01.4	23 51 39.6	23 49 05.9	23 46 28.3	10 38.8	327	56	208
−159 00	+ 9 00.0	+ 7 10.1	+ 5 22.1	23 53 36.1	23 51 04.4	23 48 28.2	10 34.9	327	56	209
−158 30	+ 9 21.7	+ 7 31.5	+ 5 43.1	23 55 30.7	23 53 01.0	23 50 26.5	10 31.0	327	55	211
−158 00	+ 9 43.6	+ 7 53.1	+ 6 04.4	23 57 23.1	23 54 55.7	23 52 22.9	10 27.1	327	54	212
−157 30	+10 05.7	+ 8 14.8	+ 6 25.8	23 59 13.4	23 56 48.3	23 54 17.6	10 23.2	327	53	213
−157 00	+10 27.9	+ 8 36.7	+ 6 47.4	0 01 01.4	23 58 38.9	23 56 10.4	10 19.2	327	52	213
−156 30	+10 50.2	+ 8 58.8	+ 7 09.1	0 02 47.3	0 00 27.4	23 58 01.2	10 15.3	327	51	214
−156 00	+11 12.7	+ 9 20.9	+ 7 31.0	0 04 30.8	0 02 13.8	23 59 50.0	10 11.4	327	51	215
−155 30	+11 35.2	+ 9 43.2	+ 7 53.0	0 06 12.1	0 03 58.0	0 01 36.8	10 07.5	328	50	216
−155 00	+11 57.7	+10 05.5	+ 8 15.1	0 07 51.1	0 05 40.1	0 03 21.6	10 03.6	328	49	217
−125 00	+31 23.9	+29 29.6	+27 36.9	0 51 29.9	0 52 04.6	0 52 28.9	7 33.8	364	7	239
−124 30	+31 38.6	+29 44.6	+27 51.8	0 51 35.6	0 52 13.7	0 52 39.5	7 32.4	364	7	239
−124 00	+31 53.2	+29 59.4	+28 06.6	0 51 41.3	0 52 21.7	0 52 49.2	7 31.0	365	6	239
−123 30	+32 07.9	+30 14.0	+28 21.3	0 51 47.0	0 52 28.7	0 52 58.1	7 29.7	366	6	240
−123 00	+32 22.6	+30 28.3	+28 35.6	0 51 52.7	0 52 33.9	0 53 05.3	7 28.5	366	5	240
−122 30	+32 37.3	+30 42.4	+28 49.8	0 51 58.4	0 52 38.7	0 53 12.2	7 27.2	367	5	240
−122 00	.. .. .	+30 56.6	+29 04.1	. .. .. .	0 52 43.5	0 53 19.1	7 26.0	368	4	240
−121 30	.. .. .	+31 10.7	+29 18.3	. .. .. .	0 52 48.4	0 53 26.0	7 24.7	368	4	241
−121 00	.. .. .	+31 24.9	.. .. .	. .. .. .	0 52 53.2	. .. .. .	7 23.5	369	3	241
−120 30	.. .. .	+31 39.0	.. .. .	. .. .. .	0 52 58.0	. .. .. .	7 22.2	370	3	241

CORRECTIONS TO U.T. AND LATITUDE FOR ELEVATIONS ABOVE SEA LEVEL

Longitude	Latitude Corr.	U.T. Corr.	Longitude	Latitude Corr.	U.T. Corr.	Longitude	Latitude Corr.	U.T. Corr.
° ′	″	s	° ′	″	s	° ′	″	s
+142 00	−2.442	−0.364	+166 00	−3.424	−0.406	−170 00	−4.711	−0.070
+142 30	−2.508	−0.408	+166 30	−3.461	−0.405	−169 30	−4.687	−0.057
+143 00	−2.530	−0.422	+167 00	−3.499	−0.403	−169 00	−4.660	−0.043
+143 30	−2.495	−0.399	+167 30	−3.537	−0.401	−168 30	−4.629	−0.029
+144 00	−2.494	−0.394	+168 00	−3.576	−0.399	−168 00	−4.594	−0.015
+144 30	−2.497	−0.393	+168 30	−3.615	−0.397	−167 30	−4.556	−0.001
+145 00	−2.508	−0.397	+169 00	−3.654	−0.395	−167 00	−4.515	+0.013
+145 30	−2.513	−0.396	+169 30	−3.694	−0.392	−166 30	−4.470	+0.027
+146 00	−2.524	−0.398	+170 00	−3.735	−0.389	−166 00	−4.422	+0.041
+146 30	−2.532	−0.399	+170 30	−3.775	−0.386	−165 30	−4.372	+0.055
+147 00	−2.542	−0.401	+171 00	−3.816	−0.383	−165 00	−4.318	+0.069
+147 30	−2.552	−0.401	+171 30	−3.858	−0.380	−164 30	−4.261	+0.082
+148 00	−2.563	−0.403	+172 00	−3.899	−0.376	−164 00	−4.203	+0.096
+148 30	−2.575	−0.404	+172 30	−3.941	−0.373	−163 30	−4.142	+0.109
+149 00	−2.587	−0.405	+173 00	−3.982	−0.369	−163 00	−4.079	+0.123
+149 30	−2.600	−0.406	+173 30	−4.024	−0.365	−162 30	−4.014	+0.136
+150 00	−2.613	−0.407	+174 00	−4.065	−0.360	−162 00	−3.948	+0.149
+150 30	−2.627	−0.408	+174 30	−4.107	−0.356	−161 30	−3.881	+0.161
+151 00	−2.642	−0.409	+175 00	−4.148	−0.351	−161 00	−3.813	+0.173
+151 30	−2.658	−0.409	+175 30	−4.188	−0.346	−160 30	−3.744	+0.185
+152 00	−2.674	−0.410	+176 00	−4.229	−0.340	−160 00	−3.675	+0.197
+152 30	−2.691	−0.411	+176 30	−4.269	−0.335	−159 30	−3.606	+0.208
+153 00	−2.708	−0.412	+177 00	−4.308	−0.329	−159 00	−3.537	+0.219
+153 30	−2.727	−0.412	+177 30	−4.346	−0.322	−158 30	−3.468	+0.230
+154 00	−2.746	−0.413	+178 00	−4.384	−0.316	−158 00	−3.400	+0.240
+154 30	−2.765	−0.414	+178 30	−4.421	−0.309	−157 30	−3.333	+0.250
+155 00	−2.786	−0.414	+179 00	−4.456	−0.302	−157 00	−3.267	+0.259
+155 30	−2.807	−0.415	+179 30	−4.491	−0.295	−156 30	−3.202	+0.268
+156 00	−2.829	−0.415	+180 00	−4.524	−0.287	−156 00	−3.138	+0.277
+156 30	−2.852	−0.416	−179 30	−4.556	−0.279	−155 30	−3.076	+0.285
+157 00	−2.875	−0.416	−179 00	−4.586	−0.271	−155 00	−3.015	+0.293
+157 30	−2.900	−0.416	−178 30	−4.615	−0.262	−125 00	−2.344	+0.385
+158 00	−2.924	−0.416	−178 00	−4.642	−0.254	−124 30	−2.484	+0.374
+158 30	−2.950	−0.416	−177 30	−4.666	−0.244	−124 00	−2.787	+0.348
+159 00	−2.977	−0.416	−177 00	−4.689	−0.235	−123 30	−2.880	+0.340
+159 30	−3.004	−0.416	−176 30	−4.710	−0.225	−123 00	−2.419	+0.379
+160 00	−3.032	−0.416	−176 00	−4.728	−0.215	−122 30	−1.848	+0.426
+160 30	−3.061	−0.416	−175 30	−4.743	−0.204			
+161 00	−3.090	−0.416	−175 00	−4.756	−0.194			
+161 30	−3.120	−0.415	−174 30	−4.766	−0.182			
+162 00	−3.151	−0.415	−174 00	−4.773	−0.171			
+162 30	−3.183	−0.414	−173 30	−4.777	−0.159			
+163 00	−3.215	−0.413	−173 00	−4.778	−0.147			
+163 30	−3.248	−0.412	−172 30	−4.775	−0.135			
+164 00	−3.282	−0.412	−172 00	−4.770	−0.123			
+164 30	−3.317	−0.410	−171 30	−4.760	−0.110			
+165 00	−3.352	−0.409	−171 00	−4.747	−0.097			
+165 30	−3.388	−0.408	−170 30	−4.731	−0.084			

These corrections to latitude and time are to be applied to the corresponding surface data on page 24 to correct for elevation. *The units are seconds of arc or seconds of time per thousand feet.*

Example: Elevation 35000 ft. at longitude +149°.

Lat. corr.: $-2''.587 \times 35 = -90''.6 = -1'.5$

Time corr.: $-0^{s}.405 \times 35 = -14^{s}.2$

Hence, for the longitude +149° tabular entry on page 24, the three latitude values should be shifted south by $1'.5$, and the three times advanced (made earlier) by $14^{s}.2$.

PATH OF CENTRAL LINE AT FLYING ALTITUDES

U.T.	10000 Ft.		40000 Ft.		U.T.	10000 Ft.		40000 Ft.	
	Latitude	Longitude	Latitude	Longitude		Latitude	Longitude	Latitude	Longitude
h m	° ′	° ′	° ′	° ′	h m	° ′	° ′	° ′	° ′
Limits	+11 32.0	+137 08.1	+11 29.9	+137 10.0	22 10	− 1 13.9	+176 34.4	− 1 16.2	+176 37.5
21 16	+10 56.1	+138 33.0	+10 10.0	+140 19.2	22 11	− 1 14.9	+176 52.7	− 1 17.2	+176 55.7
21 17	+ 8 46.3	+143 41.8	+ 8 30.8	+144 15.9	22 12	− 1 15.7	+177 10.8	− 1 18.0	+177 13.7
21 18	+ 7 44.3	+146 11.2	+ 7 33.0	+146 35.8	22 13	− 1 16.4	+177 28.7	− 1 18.7	+177 31.5
21 19	+ 6 58.2	+148 03.9	+ 6 48.8	+148 24.0	22 14	− 1 17.0	+177 46.4	− 1 19.3	+177 49.2
21 20	+ 6 20.4	+149 37.5	+ 6 12.2	+149 54.8	22 15	− 1 17.4	+178 03.9	− 1 19.6	+178 06.7
21 21	+ 5 48.0	+150 58.7	+ 5 40.6	+151 14.1	22 16	− 1 17.7	+178 21.3	− 1 19.9	+178 24.0
21 22	+ 5 19.5	+152 11.2	+ 5 12.7	+152 25.2	22 17	− 1 17.8	+178 38.5	− 1 20.0	+178 41.1
21 23	+ 4 53.9	+153 17.1	+ 4 47.6	+153 30.0	22 18	− 1 17.7	+178 55.5	− 1 19.9	+178 58.1
21 24	+ 4 30.7	+154 17.7	+ 4 24.8	+154 29.7	22 19	− 1 17.6	+179 12.4	− 1 19.8	+179 14.9
21 25	+ 4 09.5	+155 14.1	+ 4 03.9	+155 25.4	22 20	− 1 17.3	+179 29.2	− 1 19.4	+179 31.6
21 26	+ 3 49.9	+156 07.0	+ 3 44.6	+156 17.6	22 21	− 1 16.8	+179 45.8	− 1 19.0	+179 48.1
21 27	+ 3 31.7	+156 56.8	+ 3 26.6	+157 06.8	22 22	− 1 16.2	−179 57.8	− 1 18.4	−179 55.5
21 28	+ 3 14.7	+157 44.0	+ 3 09.8	+157 53.5	22 23	− 1 15.5	−179 41.5	− 1 17.7	−179 39.2
21 29	+ 2 58.8	+158 28.9	+ 2 54.1	+158 38.0	22 24	− 1 14.7	−179 25.3	− 1 16.8	−179 23.1
21 30	+ 2 43.9	+159 11.8	+ 2 39.4	+159 20.5	22 25	− 1 13.7	−179 09.3	− 1 15.8	−179 07.1
21 31	+ 2 29.8	+159 52.9	+ 2 25.5	+160 01.2	22 26	− 1 12.6	−178 53.3	− 1 14.7	−178 51.2
21 32	+ 2 16.6	+160 32.4	+ 2 12.4	+160 40.4	22 27	− 1 11.4	−178 37.5	− 1 13.5	−178 35.4
21 33	+ 2 04.0	+161 10.4	+ 1 60.0	+161 18.1	22 28	− 1 10.0	−178 21.8	− 1 12.1	−178 19.8
21 34	+ 1 52.2	+161 47.0	+ 1 48.2	+161 54.5	22 29	− 1 08.5	−178 06.3	− 1 10.7	−178 04.3
21 35	+ 1 40.9	+162 22.5	+ 1 37.1	+162 29.7	22 30	− 1 06.9	−177 50.8	− 1 09.0	−177 48.9
21 36	+ 1 30.3	+162 56.8	+ 1 26.5	+163 03.8	22 31	− 1 05.2	−177 35.4	− 1 07.3	−177 33.6
21 37	+ 1 20.1	+163 30.1	+ 1 16.5	+163 36.9	22 32	− 1 03.4	−177 20.2	− 1 05.5	−177 18.3
21 38	+ 1 10.5	+164 02.5	+ 1 06.9	+164 09.0	22 33	− 1 01.4	−177 05.0	− 1 03.5	−177 03.2
21 39	+ 1 01.3	+164 33.9	+ 0 57.8	+164 40.3	22 34	− 0 59.3	−176 50.0	− 1 01.4	−176 48.2
21 40	+ 0 52.6	+165 04.5	+ 0 49.2	+165 10.7	22 35	− 0 57.1	−176 35.0	− 0 59.2	−176 33.3
21 41	+ 0 44.3	+165 34.4	+ 0 40.9	+165 40.4	22 36	− 0 54.8	−176 20.1	− 0 56.9	−176 18.5
21 42	+ 0 36.4	+166 03.5	+ 0 33.1	+166 09.3	22 37	− 0 52.4	−176 05.3	− 0 54.5	−176 03.7
21 43	+ 0 28.8	+166 31.9	+ 0 25.6	+166 37.6	22 38	− 0 49.8	−175 50.6	− 0 51.9	−175 49.1
21 44	+ 0 21.7	+166 59.7	+ 0 18.5	+167 05.2	22 39	− 0 47.2	−175 36.0	− 0 49.3	−175 34.5
21 45	+ 0 14.8	+167 26.9	+ 0 11.8	+167 32.3	22 40	− 0 44.4	−175 21.5	− 0 46.5	−175 20.0
21 46	+ 0 08.3	+167 53.5	+ 0 05.3	+167 58.8	22 41	− 0 41.5	−175 07.0	− 0 43.6	−175 05.6
21 47	+ 0 02.2	+168 19.6	− 0 00.8	+168 24.7	22 42	− 0 38.5	−174 52.6	− 0 40.6	−174 51.2
21 48	− 0 03.7	+168 45.1	− 0 06.7	+168 50.1	22 43	− 0 35.4	−174 38.3	− 0 37.5	−174 36.9
21 49	− 0 09.3	+169 10.2	− 0 12.2	+169 15.1	22 44	− 0 32.2	−174 24.0	− 0 34.3	−174 22.7
21 50	− 0 14.6	+169 34.8	− 0 17.5	+169 39.5	22 45	− 0 28.9	−174 09.8	− 0 31.0	−174 08.6
21 51	− 0 19.7	+169 58.9	− 0 22.5	+170 03.6	22 46	− 0 25.5	−173 55.7	− 0 27.5	−173 54.5
21 52	− 0 24.5	+170 22.7	− 0 27.2	+170 27.2	22 47	− 0 21.9	−173 41.6	− 0 24.0	−173 40.5
21 53	− 0 29.0	+170 46.0	− 0 31.7	+170 50.4	22 48	− 0 18.3	−173 27.6	− 0 20.4	−173 26.5
21 54	− 0 33.3	+171 08.9	− 0 36.0	+171 13.3	22 49	− 0 14.5	−173 13.7	− 0 16.6	−173 12.6
21 55	− 0 37.3	+171 31.5	− 0 40.0	+171 35.7	22 50	− 0 10.6	−172 59.8	− 0 12.7	−172 58.8
21 56	− 0 41.2	+171 53.7	− 0 43.8	+171 57.8	22 51	− 0 06.7	−172 45.9	− 0 08.8	−172 45.0
21 57	− 0 44.8	+172 15.6	− 0 47.4	+172 19.6	22 52	− 0 02.6	−172 32.1	− 0 04.7	−172 31.2
21 58	− 0 48.2	+172 37.1	− 0 50.7	+172 41.1	22 53	+ 0 01.6	−172 18.4	− 0 00.5	−172 17.5
21 59	− 0 51.3	+172 58.4	− 0 53.9	+173 02.2	22 54	+ 0 05.9	−172 04.7	+ 0 03.7	−172 03.8
22 00	− 0 54.3	+173 19.3	− 0 56.8	+173 23.1	22 55	+ 0 10.3	−171 51.0	+ 0 08.1	−171 50.2
22 01	− 0 57.1	+173 39.9	− 0 59.6	+173 43.7	22 56	+ 0 14.8	−171 37.4	+ 0 12.6	−171 36.6
22 02	− 0 59.7	+174 00.3	− 1 02.2	+174 04.0	22 57	+ 0 19.4	−171 23.8	+ 0 17.2	−171 23.1
22 03	− 1 02.1	+174 20.4	− 1 04.5	+174 24.0	22 58	+ 0 24.1	−171 10.3	+ 0 21.9	−171 09.6
22 04	− 1 04.3	+174 40.3	− 1 06.7	+174 43.7	22 59	+ 0 28.9	−170 56.8	+ 0 26.7	−170 56.1
22 05	− 1 06.3	+174 59.9	− 1 08.7	+175 03.3	23 00	+ 0 33.8	−170 43.3	+ 0 31.6	−170 42.7
22 06	− 1 08.2	+175 19.2	− 1 10.5	+175 22.6	23 01	+ 0 38.8	−170 29.8	+ 0 36.6	−170 29.3
22 07	− 1 09.8	+175 38.3	− 1 12.2	+175 41.6	23 02	+ 0 43.9	−170 16.4	+ 0 41.8	−170 15.9
22 08	− 1 11.3	+175 57.3	− 1 13.7	+176 00.4	23 03	+ 0 49.1	−170 03.0	+ 0 47.0	−170 02.5
22 09	− 1 12.7	+176 15.9	− 1 15.0	+176 19.1	23 04	+ 0 54.5	−169 49.6	+ 0 52.3	−169 49.2

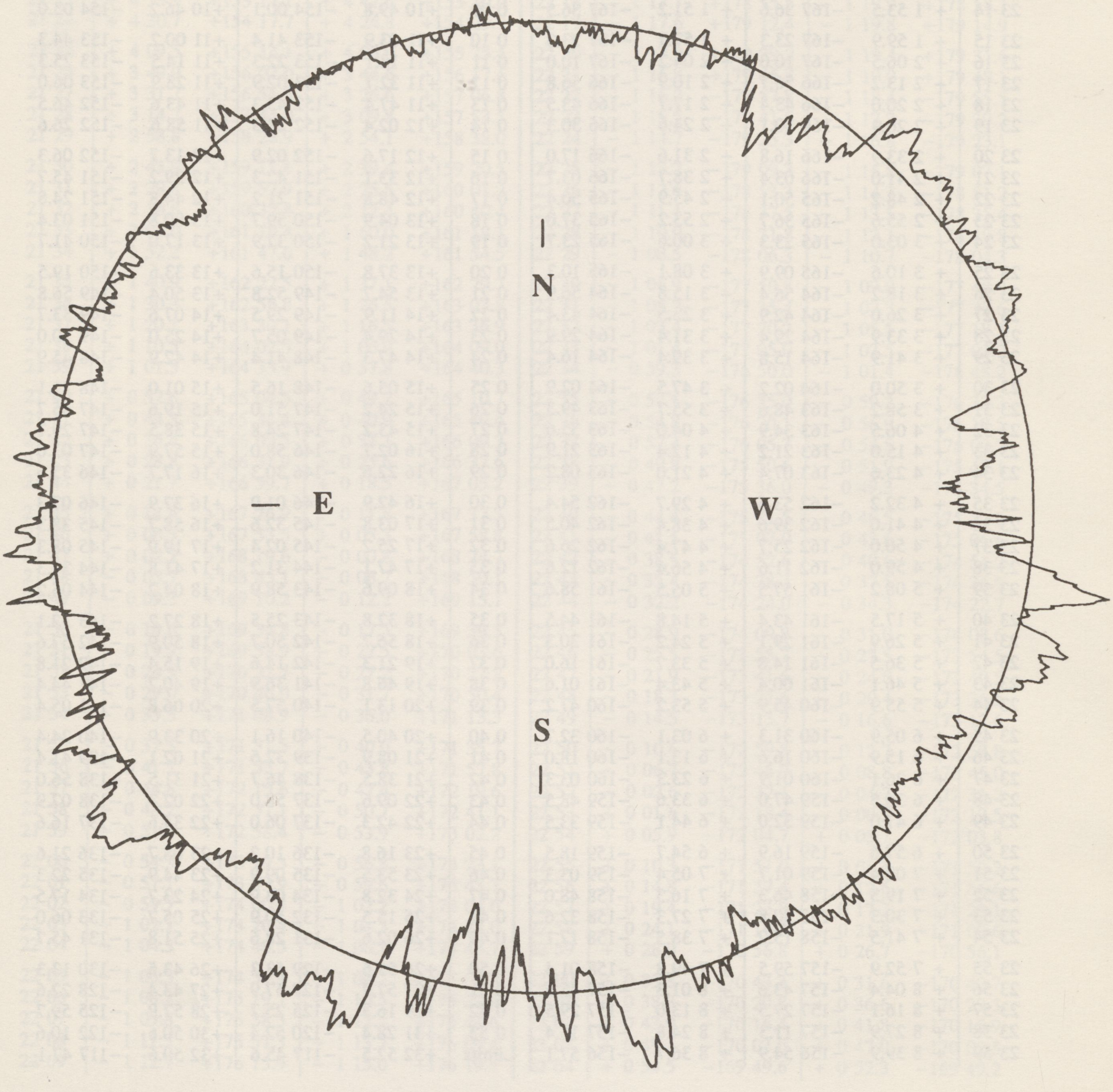
PATH OF CENTRAL LINE AT FLYING ALTITUDES

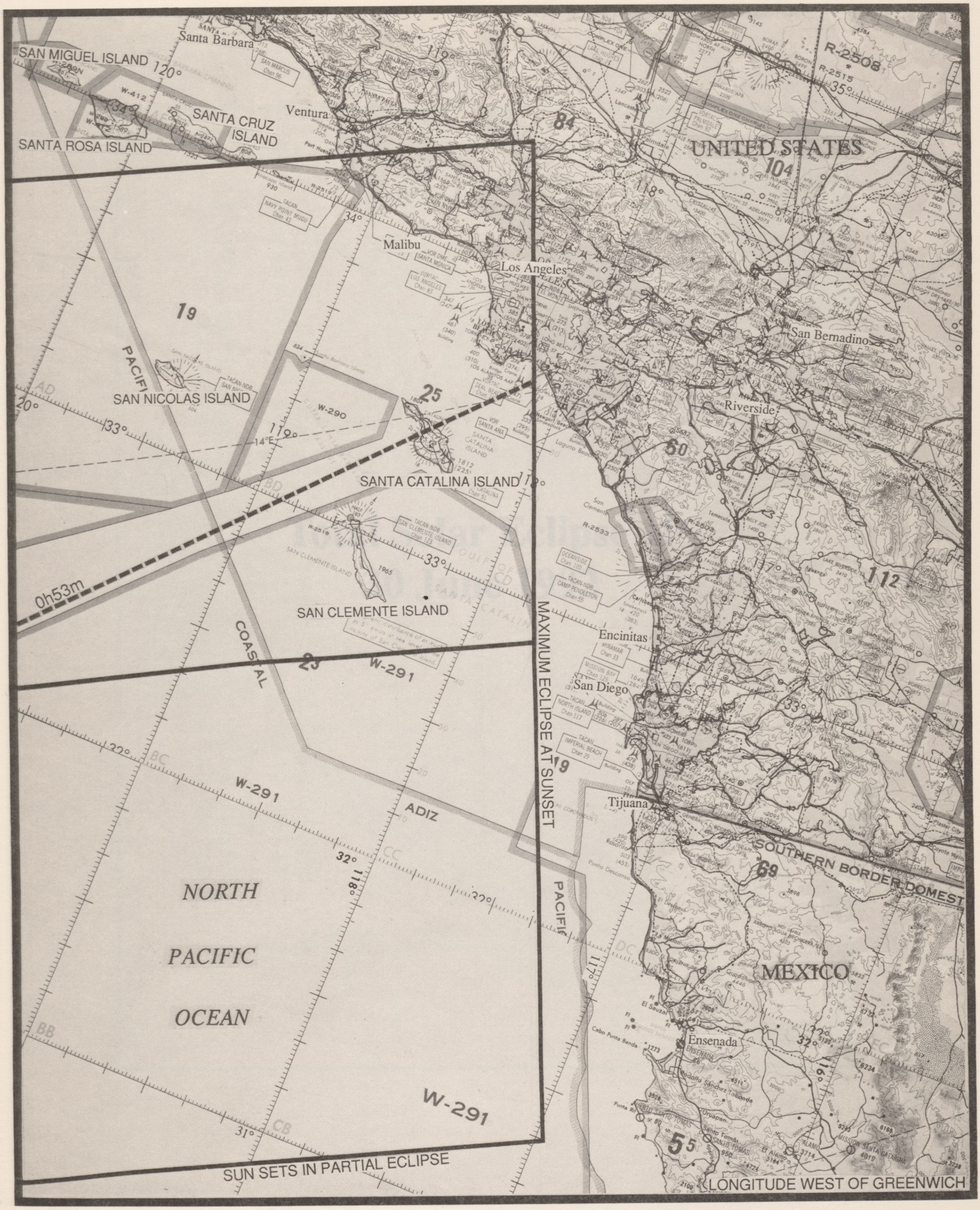
U.T.	10000 Ft.		40000 Ft.		U.T.	10000 Ft.		40000 Ft.	
	Latitude	Longitude	Latitude	Longitude		Latitude	Longitude	Latitude	Longitude
h m	° ′	° ′	° ′	° ′	h m	° ′	° ′	° ′	° ′
23 05	+ 0 59.9	−169 36.3	+ 0 57.7	−169 35.9	0 00	+ 8 52.1	−156 38.4	+ 8 48.9	−156 40.6
23 06	+ 1 05.4	−169 22.9	+ 1 03.2	−169 22.6	0 01	+ 9 04.4	−156 21.6	+ 9 01.2	−156 23.9
23 07	+ 1 11.1	−169 09.6	+ 1 08.9	−169 09.3	0 02	+ 9 16.9	−156 04.7	+ 9 13.6	−156 07.0
23 08	+ 1 16.8	−168 56.3	+ 1 14.6	−168 56.0	0 03	+ 9 29.6	−155 47.6	+ 9 26.3	−155 50.0
23 09	+ 1 22.7	−168 43.0	+ 1 20.5	−168 42.7	0 04	+ 9 42.5	−155 30.2	+ 9 39.1	−155 32.7
23 10	+ 1 28.6	−168 29.7	+ 1 26.4	−168 29.5	0 05	+ 9 55.6	−155 12.7	+ 9 52.1	−155 15.2
23 11	+ 1 34.7	−168 16.4	+ 1 32.4	−168 16.2	0 06	+10 08.8	−154 54.9	+10 05.4	−154 57.5
23 12	+ 1 40.8	−168 03.1	+ 1 38.6	−168 03.0	0 07	+10 22.3	−154 36.9	+10 18.8	−154 39.6
23 13	+ 1 47.1	−167 49.8	+ 1 44.8	−167 49.8	0 08	+10 35.9	−154 18.6	+10 32.4	−154 21.4
23 14	+ 1 53.5	−167 36.6	+ 1 51.2	−167 36.5	0 09	+10 49.8	−154 00.1	+10 46.2	−154 03.0
23 15	+ 1 59.9	−167 23.3	+ 1 57.7	−167 23.3	0 10	+11 03.9	−153 41.4	+11 00.2	−153 44.3
23 16	+ 2 06.5	−167 10.0	+ 2 04.2	−167 10.0	0 11	+11 18.1	−153 22.3	+11 14.5	−153 25.3
23 17	+ 2 13.2	−166 56.7	+ 2 10.9	−166 56.8	0 12	+11 32.7	−153 02.9	+11 28.9	−153 06.0
23 18	+ 2 20.0	−166 43.4	+ 2 17.7	−166 43.5	0 13	+11 47.4	−152 43.3	+11 43.6	−152 46.5
23 19	+ 2 26.9	−166 30.1	+ 2 24.6	−166 30.3	0 14	+12 02.4	−152 23.3	+11 58.6	−152 26.6
23 20	+ 2 33.9	−166 16.8	+ 2 31.6	−166 17.0	0 15	+12 17.6	−152 02.9	+12 13.7	−152 06.3
23 21	+ 2 41.0	−166 03.4	+ 2 38.7	−166 03.7	0 16	+12 33.1	−151 42.3	+12 29.2	−151 45.7
23 22	+ 2 48.2	−165 50.1	+ 2 45.9	−165 50.4	0 17	+12 48.8	−151 21.2	+12 44.8	−151 24.8
23 23	+ 2 55.6	−165 36.7	+ 2 53.2	−165 37.0	0 18	+13 04.9	−150 59.7	+13 00.8	−151 03.4
23 24	+ 3 03.0	−165 23.3	+ 3 00.6	−165 23.7	0 19	+13 21.2	−150 37.9	+13 17.0	−150 41.7
23 25	+ 3 10.6	−165 09.9	+ 3 08.1	−165 10.3	0 20	+13 37.8	−150 15.6	+13 33.6	−150 19.5
23 26	+ 3 18.2	−164 56.4	+ 3 15.8	−164 56.9	0 21	+13 54.7	−149 52.8	+13 50.4	−149 56.8
23 27	+ 3 26.0	−164 42.9	+ 3 23.5	−164 43.4	0 22	+14 11.9	−149 29.5	+14 07.6	−149 33.7
23 28	+ 3 33.9	−164 29.4	+ 3 31.4	−164 29.9	0 23	+14 29.4	−149 05.7	+14 25.0	−149 10.0
23 29	+ 3 41.9	−164 15.8	+ 3 39.4	−164 16.4	0 24	+14 47.3	−148 41.4	+14 42.9	−148 45.9
23 30	+ 3 50.0	−164 02.2	+ 3 47.5	−164 02.9	0 25	+15 05.6	−148 16.5	+15 01.0	−148 21.1
23 31	+ 3 58.2	−163 48.6	+ 3 55.7	−163 49.3	0 26	+15 24.2	−147 51.0	+15 19.6	−147 55.7
23 32	+ 4 06.5	−163 34.9	+ 4 04.0	−163 35.6	0 27	+15 43.2	−147 24.8	+15 38.5	−147 29.7
23 33	+ 4 15.0	−163 21.2	+ 4 12.4	−163 21.9	0 28	+16 02.7	−146 58.0	+15 57.9	−147 03.0
23 34	+ 4 23.6	−163 07.4	+ 4 21.0	−163 08.2	0 29	+16 22.6	−146 30.3	+16 17.7	−146 35.6
23 35	+ 4 32.2	−162 53.5	+ 4 29.7	−162 54.4	0 30	+16 42.9	−146 01.9	+16 37.9	−146 07.3
23 36	+ 4 41.0	−162 39.6	+ 4 38.4	−162 40.5	0 31	+17 03.8	−145 32.6	+16 58.7	−145 38.3
23 37	+ 4 50.0	−162 25.7	+ 4 47.4	−162 26.6	0 32	+17 25.2	−145 02.4	+17 19.9	−145 08.3
23 38	+ 4 59.0	−162 11.6	+ 4 56.4	−162 12.6	0 33	+17 47.1	−144 31.2	+17 41.8	−144 37.3
23 39	+ 5 08.2	−161 57.5	+ 5 05.5	−161 58.6	0 34	+18 09.6	−143 58.9	+18 04.2	−144 05.2
23 40	+ 5 17.5	−161 43.4	+ 5 14.8	−161 44.5	0 35	+18 32.8	−143 25.5	+18 27.2	−143 32.1
23 41	+ 5 26.9	−161 29.1	+ 5 24.2	−161 30.3	0 36	+18 56.7	−142 50.7	+18 50.9	−142 57.6
23 42	+ 5 36.5	−161 14.8	+ 5 33.7	−161 16.0	0 37	+19 21.3	−142 14.6	+19 15.4	−142 21.8
23 43	+ 5 46.1	−161 00.4	+ 5 43.4	−161 01.6	0 38	+19 46.8	−141 36.9	+19 40.7	−141 44.4
23 44	+ 5 55.9	−160 45.9	+ 5 53.2	−160 47.2	0 39	+20 13.1	−140 57.5	+20 06.8	−141 05.4
23 45	+ 6 05.9	−160 31.3	+ 6 03.1	−160 32.7	0 40	+20 40.5	−140 16.1	+20 33.9	−140 24.4
23 46	+ 6 15.9	−160 16.6	+ 6 13.1	−160 18.0	0 41	+21 08.9	−139 32.6	+21 02.1	−139 41.4
23 47	+ 6 26.1	−160 01.9	+ 6 23.3	−160 03.3	0 42	+21 38.5	−138 46.7	+21 31.5	−138 56.0
23 48	+ 6 36.5	−159 47.0	+ 6 33.6	−159 48.5	0 43	+22 09.6	−137 58.0	+22 02.3	−138 07.9
23 49	+ 6 47.0	−159 32.0	+ 6 44.1	−159 33.5	0 44	+22 42.3	−137 06.0	+22 34.6	−137 16.6
23 50	+ 6 57.6	−159 16.9	+ 6 54.7	−159 18.5	0 45	+23 16.8	−136 10.2	+23 08.7	−136 21.6
23 51	+ 7 08.4	−159 01.7	+ 7 05.4	−159 03.3	0 46	+23 53.5	−135 09.9	+23 44.9	−135 22.3
23 52	+ 7 19.3	−158 46.3	+ 7 16.3	−158 48.0	0 47	+24 32.8	−134 03.9	+24 23.7	−134 17.5
23 53	+ 7 30.3	−158 30.8	+ 7 27.3	−158 32.6	0 48	+25 15.5	−132 50.9	+25 05.7	−133 06.0
23 54	+ 7 41.5	−158 15.2	+ 7 38.5	−158 17.1	0 49	+26 02.6	−131 28.6	+25 51.8	−131 45.7
23 55	+ 7 52.9	−157 59.5	+ 7 49.8	−158 01.4	0 50	+26 55.6	−129 53.3	+26 43.5	−130 13.3
23 56	+ 8 04.4	−157 43.6	+ 8 01.3	−157 45.5	0 51	+27 57.7	−127 57.9	+27 43.4	−128 22.6
23 57	+ 8 16.1	−157 27.5	+ 8 13.0	−157 29.5	0 52	+29 16.3	−125 25.7	+28 57.9	−125 59.7
23 58	+ 8 27.9	−157 11.3	+ 8 24.8	−157 13.4	0 53	+31 28.4	−120 52.4	+30 50.6	−122 10.6
23 59	+ 8 39.9	−156 54.9	+ 8 36.7	−156 57.1	Limits	+32 52.5	−117 45.6	+32 50.6	−117 47.1

LUNAR LIMB PROFILE

Radial Scale at Limb: approx. 4 arcsec/inch

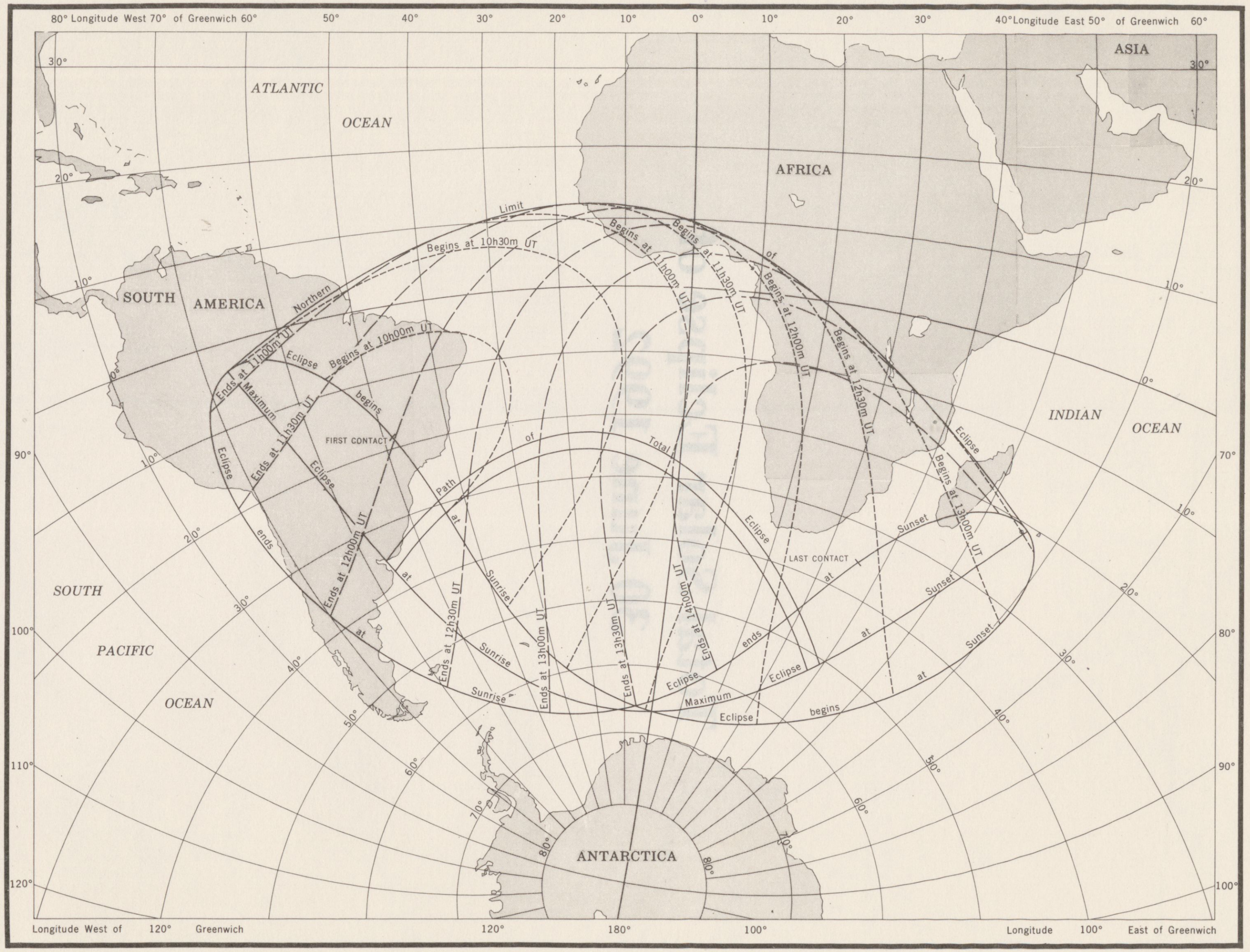
true limb: *irregular curve*
mean limb: *smooth curve*




Santa Barbara
SAN MIGUEL ISLAND
120°
SANTA CRUZ ISLAND
Ventura
SANTA ROSA ISLAND
R-2508
R-2515
35°
84
UNITED STATES
104
118°
34°
Malibu
Los Angeles
19
San Bernadino
Riverside
PACIFIC
SAN NICOLAS ISLAND
25
W-290
20°
33°
119°
60
SANTA CATALINA ISLAND
117°
R-2533
33°
112
0h53m
SAN CLEMENTE ISLAND
COASTAL
MAXIMUM ECLIPSE AT SUNSET
Encinitas
23
W-291
San Diego
33°
19
32°
W-291
ADIZ
Tijuana
SOUTHERN BORDER DOMEST
32°
118°
69
NORTH
PACIFIC
OCEAN
32°
PACIFIC
117°
MEXICO
Ensenada
32°
116°
W-291
31°
55
SUN SETS IN PARTIAL ECLIPSE
LONGITUDE WEST OF GREENWICH

Total Solar Eclipse of 30 June 1992

TOTAL SOLAR ECLIPSE OF 30 JUNE 1992


80° Longitude West 70° of Greenwich 60°
50°
40°
30°
20°
10°
0°
10°
20°
30°
40° Longitude East 50° of Greenwich 60°
ATLANTIC
OCEAN
AFRICA
ASIA
SOUTH
AMERICA
INDIAN
OCEAN
SOUTH
PACIFIC
OCEAN
ANTARCTICA
Limit of Northern Eclipse
Begins at 10h00m UT
Begins at 10h30m UT
Begins at 11h00m UT
Begins at 11h30m UT
Begins at 12h00m UT
Begins at 12h30m UT
Begins at 13h00m UT
Ends at 11h00m UT
Ends at 11h30m UT
Ends at 12h00m UT
Ends at 12h30m UT
Ends at 13h00m UT
Ends at 13h30m UT
Ends at 14h00m UT
Maximum Eclipse at Sunrise
Maximum Eclipse at Sunset
Eclipse begins at Sunrise
Eclipse begins at Sunset
Eclipse ends at Sunrise
Eclipse ends at Sunset
Path of Total Eclipse
FIRST CONTACT
LAST CONTACT
Longitude West of 120° Greenwich
120°
180°
100°
Longitude 100° East of Greenwich
90°
100°
110°
120°
70°
80°
90°
100°

SURFACE PATH OF THE TOTAL PHASE

U.T.	Northern Limit		Central Line		Southern Limit	
	Latitude	Longitude	Latitude	Longitude	Latitude	Longitude
	° ′	° ′	° ′	° ′	° ′	° ′
Limits	−34 53.4	− 56 51.1	−35 49.2	− 56 32.5	−36 46.1	− 56 13.0
h m						
11 01	−32 32.4	− 51 38.7	.. .. .	.. .. .	.. .. .	.. .. .
11 02	−31 07.2	− 48 25.0	−34 10.6	− 52 52.1	.. .. .	.. .. .
11 03	−30 10.7	− 46 13.3	−32 28.8	− 48 59.6	.. .. .	.. .. .
11 04	−29 26.6	− 44 27.9	−31 28.3	− 46 37.3	−33 59.1	− 49 52.2
11 05	−28 49.8	− 42 58.1	−30 42.3	− 44 46.6	−32 51.5	− 47 12.6
11 10	−26 42.0	− 37 24.6	−28 16.1	− 38 30.0	−29 55.3	− 39 46.5
11 15	−25 20.7	− 33 22.9	−26 48.4	− 34 12.3	−28 19.1	− 35 08.0
11 20	−24 23.8	− 30 06.0	−25 48.2	− 30 46.6	−27 15.0	− 31 31.6
11 25	−23 43.0	− 27 16.2	−25 05.6	− 27 51.3	−26 30.0	− 28 29.8
11 30	−23 14.3	− 24 45.0	−24 35.6	− 25 16.3	−25 58.6	− 25 50.2
11 35	−22 55.2	− 22 27.0	−24 15.7	− 22 55.5	−25 37.7	− 23 26.1
11 40	−22 44.1	− 20 18.9	−24 04.1	− 20 45.3	−25 25.4	− 21 13.4
11 45	−22 40.2	− 18 18.3	−23 59.7	− 18 43.0	−25 20.6	− 19 09.2
11 50	−22 42.6	− 16 23.5	−24 01.8	− 16 46.8	−25 22.3	− 17 11.3
11 55	−22 50.9	− 14 33.1	−24 09.9	− 14 55.2	−25 30.2	− 15 18.3
12 00	−23 04.8	− 12 45.8	−24 23.7	− 13 06.9	−25 43.8	− 13 28.7
12 05	−23 24.2	− 11 00.8	−24 42.8	− 11 20.9	−26 02.8	− 11 41.5
12 10	−23 48.8	− 9 17.0	−25 07.4	− 9 36.1	−26 27.3	− 9 55.6
12 15	−24 18.6	− 7 33.7	−25 37.3	− 7 51.8	−26 57.3	− 8 10.0
12 20	−24 53.9	− 5 49.8	−26 12.6	− 6 06.8	−27 32.7	− 6 23.8
12 25	−25 34.8	− 4 04.6	−26 53.6	− 4 20.4	−28 14.0	− 4 36.0
12 30	−26 21.5	− 2 17.0	−27 40.6	− 2 31.4	−29 01.4	− 2 45.4
12 35	−27 14.6	− 0 25.7	−28 34.1	− 0 38.5	−29 55.4	− 0 50.6
12 40	−28 14.7	+ 1 30.5	−29 34.8	+ 1 19.8	−30 56.9	+ 1 10.0
12 45	−29 22.6	+ 3 33.7	−30 43.7	+ 3 25.4	−32 06.9	+ 3 18.4
12 50	−30 39.6	+ 5 46.1	−32 02.1	+ 5 41.1	−33 27.0	+ 5 37.8
12 55	−32 07.7	+ 8 11.3	−33 32.2	+ 8 10.6	−34 59.5	+ 8 12.3
13 00	−33 49.8	+ 10 54.6	−35 17.3	+ 11 00.0	−36 48.2	+ 11 08.9
13 05	−35 50.9	+ 14 04.9	−37 23.3	+ 14 19.8	−39 00.2	+ 14 40.1
13 10	−38 20.6	+ 17 59.8	−40 01.9	+ 18 31.6	−41 50.4	+ 19 13.4
13 15	−41 43.7	+ 23 24.7	−43 47.6	+ 24 38.7	−46 10.5	+ 26 25.4
13 16	−42 36.6	+ 24 51.4	−44 50.3	+ 26 24.2	−47 33.1	+ 28 48.6
13 17	−43 36.9	+ 26 31.8	−46 06.3	+ 28 34.3	−49 34.1	+ 32 25.6
13 18	−44 48.6	+ 28 33.3	−47 48.7	+ 31 34.8	.. .. .	.. .. .
13 19	−46 21.2	+ 31 14.3	.. .. .	.. .. .	.. .. .	.. .. .
13 20	−49 04.1	+ 36 10.9	.. .. .	.. .. .	.. .. .	.. .. .
Limits	−50 43.7	+ 39 22.3	−51 34.0	+ 38 37.2	−52 24.7	+ 37 49.1

For duration, path width, and altitude and azimuth of the Sun,
please see page 38, **Local Circumstances for Points on the Central Line**

ELEMENTS OF THE ECLIPSE

U.T. of geocentric conjunction in right ascension, June 30^d 12^h 23^m 21^s.929

Julian Date = 2448804.0162260344

	h m s		s		s
R.A. of Sun and Moon	6 38 57.402	Hourly motions	10.350	and	158.436
ΔT	59.012				

	° ′ ″		′ ″
Declination of Sun	+23 08 17.09	Hourly motion	− 0 09.63
Declination of Moon	+22 22 19.92	Hourly motion	− 5 51.42
Equatorial hor. par. of Sun	8.65	True semidiameter of Sun	15 43.9
Equatorial hor. par. of Moon	60 29.24	True semidiameter of Moon	16 28.9
Lunar figure offset, long.	+ 0.53		
Lunar figure offset, lat.	− 0.29		

CIRCUMSTANCES OF THE ECLIPSE

	U.T. d h m	Longitude ° ′	Latitude ° ′
Eclipse begins	June 30 9 50.9	− 48 38.9	− 18 22.2
Central eclipse begins	30 11 01.7	− 56 32.5	− 35 49.2
Central eclipse at local apparent noon	30 12 23.4	− 4 55.4	− 26 39.6
Central eclipse ends	30 13 18.9	+ 38 37.2	− 51 34.0
Eclipse ends	30 14 29.7	+ 35 52.4	− 35 19.6

Longitudes are measured positive east of Greenwich

BESSELIAN ELEMENTS, POLYNOMIAL FORM

The equations below represent simple least-squares fits to the tabular Besselian Elements.

Let t = (U.T. − 9^h) in units of hours.

These equations are valid over the range $0^h.800 \leq t \leq 5^h.658$. Do not use t outside the given range, and do not omit any terms in the series.

If μ is greater than 360°, then subtract 360°.

$$\begin{aligned}
x &= -1.92288785 + 0.56715882\,t + 0.00007879\,t^2 - 0.00000923\,t^3 \\
y &= -0.44378301 - 0.09330135\,t - 0.00013788\,t^2 + 0.00000169\,t^3 \\
\sin d &= 0.39310993 - 0.00003870\,t - 0.00000009\,t^2 \\
\cos d &= 0.91949152 + 0.00001649\,t + 0.00000006\,t^2 \\
\mu &= 314.08445448 + 14.99942367\,t + 0.00000087\,t^2 - 0.00000001\,t^3 \\
\text{Radius penumbra} &= 0.53397731 + 0.00000280\,t - 0.00001240\,t^2 \\
\text{Radius umbra} &= -0.01234610 + 0.00000254\,t - 0.00001227\,t^2 - 0.00000001\,t^3
\end{aligned}$$

BESSELIAN ELEMENTS

U.T.	Intersection of Axis of Shadow with Fundamental Plane		Direction of Axis of Shadow			Radius of Shadow on Fundamental Plane	
	x	*y*	sin *d*	cos *d*	μ	Penumbra	Umbra
h m					°		
9 20	−1.733827	−0.474899	0.393097	+0.919497	319.08426	0.533977	−0.012347
9 30	−1.639290	−0.490468	0.393091	+0.919500	321.58417	0.533976	−0.012348
9 40	−1.544750	−0.506045	0.393084	+0.919503	324.08407	0.533974	−0.012350
9 50	−1.450206	−0.521629	0.393078	+0.919505	326.58397	0.533971	−0.012353
10 00	−1.355659	−0.537221	0.393071	+0.919508	329.08388	0.533968	−0.012356
10 10	−1.261110	−0.552820	0.393065	+0.919511	331.58378	0.533964	−0.012360
10 20	−1.166558	−0.568426	0.393058	+0.919514	334.08369	0.533959	−0.012365
10 30	−1.072003	−0.584040	0.393052	+0.919516	336.58359	0.533954	−0.012370
10 40	−0.977447	−0.599660	0.393045	+0.919519	339.08350	0.533948	−0.012376
10 50	−0.882889	−0.615289	0.393039	+0.919522	341.58340	0.533941	−0.012383
11 00	−0.788329	−0.630924	0.393032	+0.919525	344.08331	0.533933	−0.012390
11 10	−0.693768	−0.646566	0.393026	+0.919528	346.58321	0.533925	−0.012398
11 20	−0.599206	−0.662215	0.393019	+0.919530	349.08311	0.533916	−0.012407
11 30	−0.504643	−0.677872	0.393013	+0.919533	351.58302	0.533907	−0.012417
11 40	−0.410079	−0.693535	0.393006	+0.919536	354.08292	0.533897	−0.012427
11 50	−0.315515	−0.709205	0.393000	+0.919539	356.58283	0.533886	−0.012438
12 00	−0.220952	−0.724882	0.392993	+0.919541	359.08273	0.533874	−0.012449
12 10	−0.126388	−0.740566	0.392986	+0.919544	1.58264	0.533862	−0.012461
12 20	−0.031825	−0.756257	0.392980	+0.919547	4.08254	0.533849	−0.012474
12 30	+0.062737	−0.771954	0.392973	+0.919550	6.58245	0.533835	−0.012488
12 40	+0.157299	−0.787659	0.392967	+0.919553	9.08235	0.533821	−0.012502
12 50	+0.251859	−0.803369	0.392960	+0.919555	11.58226	0.533806	−0.012517
13 00	+0.346417	−0.819087	0.392954	+0.919558	14.08216	0.533790	−0.012533
13 10	+0.440974	−0.834810	0.392947	+0.919561	16.58207	0.533774	−0.012549
13 20	+0.535529	−0.850541	0.392941	+0.919564	19.08197	0.533756	−0.012566
13 30	+0.630081	−0.866277	0.392934	+0.919567	21.58188	0.533739	−0.012584
13 40	+0.724631	−0.882021	0.392927	+0.919570	24.08178	0.533720	−0.012602
13 50	+0.819178	−0.897770	0.392921	+0.919572	26.58169	0.533701	−0.012621
14 00	+0.913722	−0.913526	0.392914	+0.919575	29.08159	0.533681	−0.012641
14 10	+1.008263	−0.929288	0.392908	+0.919578	31.58150	0.533660	−0.012662
14 20	+1.102800	−0.945056	0.392901	+0.919581	34.08140	0.533639	−0.012683
14 30	+1.197333	−0.960831	0.392894	+0.919584	36.58131	0.533617	−0.012705
14 40	+1.291862	−0.976611	0.392888	+0.919586	39.08122	0.533595	−0.012727
14 50	+1.386387	−0.992398	0.392881	+0.919589	41.58112	0.533571	−0.012750
15 00	+1.480908	−1.008191	0.392874	+0.919592	44.08103	0.533547	−0.012774

tan f_1	0.004598
tan f_2	0.004575
μ′	0.261789 radians per hour
d′	−0.000043 radians per hour

LOCAL CIRCUMSTANCES FOR POINTS ON THE CENTRAL LINE

Maximum Eclipse					Central Line		First Contact		
U.T.	Duration	Path Width	Sun's Alt.	Sun's Az.	Longitude	Latitude	U.T.	*P*	*V*
h m	m s	km	°	°	° ′	° ′	h m s	°	°
11 02	3 07.2	215	3	59	− 52 52.0	−34 10.5	.. ..	...	...
11 03	3 18.3	221	7	57	− 48 59.5	−32 28.8	.. ..	...	...
11 04	3 25.6	225	10	55	− 46 37.3	−31 28.2	.. ..	...	...
11 05	3 31.6	228	12	54	− 44 46.5	−30 42.3	.. ..	...	...
11 10	3 54.1	242	18	50	− 38 30.0	−28 16.0	9 59 40.0	272	36
11 15	4 11.0	253	23	46	− 34 12.3	−26 48.3	10 01 37.7	272	37
11 20	4 25.2	262	27	43	− 30 46.6	−25 48.2	10 04 00.9	273	39
11 25	4 37.3	270	30	40	− 27 51.3	−25 05.5	10 06 41.2	274	41
11 30	4 47.9	278	32	37	− 25 16.2	−24 35.6	10 09 34.8	274	43
11 35	4 57.0	285	34	34	− 22 55.4	−24 15.6	10 12 39.8	275	45
11 40	5 04.8	290	36	31	− 20 45.2	−24 04.0	10 15 55.3	276	48
11 45	5 11.3	295	38	27	− 18 43.0	−23 59.6	10 19 21.1	276	51
11 50	5 16.6	298	39	24	− 16 46.8	−24 01.8	10 22 56.9	277	53
11 55	5 20.6	300	40	21	− 14 55.2	−24 09.9	10 26 43.0	278	56
12 00	5 23.5	301	41	17	− 13 06.9	−24 23.6	10 30 39.8	279	60
12 05	5 25.1	300	41	13	− 11 20.8	−24 42.8	10 34 47.7	280	63
12 10	5 25.5	299	41	10	− 9 36.1	−25 07.3	10 39 07.2	280	67
12 15	5 24.8	296	41	6	− 7 51.7	−25 37.2	10 43 39.1	281	70
12 20	5 22.9	293	41	2	− 6 06.8	−26 12.6	10 48 23.9	282	74
12 25	5 19.8	288	40	359	− 4 20.4	−26 53.6	10 53 22.5	283	79
12 30	5 15.7	284	39	355	− 2 31.3	−27 40.6	10 58 35.6	284	83
12 35	5 10.3	278	38	352	− 0 38.4	−28 34.1	11 04 04.0	284	87
12 40	5 03.9	273	36	348	+ 1 19.7	−29 34.8	11 09 48.7	285	92
12 45	4 56.3	267	35	345	+ 3 25.4	−30 43.6	11 15 50.8	286	97
12 50	4 47.5	261	32	341	+ 5 41.0	−32 02.1	11 22 11.5	287	102
12 55	4 37.5	255	30	338	+ 8 10.6	−33 32.2	11 28 52.7	287	107
13 00	4 26.0	249	27	334	+ 11 00.0	−35 17.3	11 35 57.0	288	112
13 05	4 12.7	242	23	330	+ 14 19.8	−37 23.2	11 43 29.2	288	117
13 10	3 56.9	235	19	326	+ 18 31.5	−40 01.9	11 51 39.3	288	121
13 15	3 36.3	226	13	320	+ 24 38.7	−43 47.5	12 00 57.0	288	126
13 16	3 30.9	224	11	319	+ 26 24.1	−44 50.3	12 03 05.1	288	127
13 17	3 24.7	222	9	317	+ 28 34.2	−46 06.2	12 05 25.3	288	129
13 18	3 16.6	219	6	315	+ 31 34.8	−47 48.7	12 08 09.4	288	130

The magnitude is 1 or greater and the obscuration is 100% for all points.

LOCAL CIRCUMSTANCES FOR POINTS ON THE CENTRAL LINE

U.T. at Maximum	Second Contact			Third Contact			Fourth Contact		
	U.T.	P	V	U.T.	P	V	U.T.	P	V
h m	h m s	°	°	h m s	°	°	h m s	°	°
11 02	11 00 26.7	92	221	11 03 34.0	272	41	12 11 42.6	93	231
11 03	11 01 21.2	92	222	11 04 39.5	272	42	12 15 14.7	93	233
11 04	11 02 17.5	92	222	11 05 43.2	272	43	12 17 54.4	93	234
11 05	11 03 14.5	92	223	11 06 46.2	272	43	12 20 15.4	94	236
11 10	11 08 03.4	93	226	11 11 57.5	273	46	12 30 08.4	95	242
11 15	11 12 54.9	94	229	11 17 06.0	274	50	12 38 36.4	96	248
11 20	11 17 47.9	95	232	11 22 13.1	275	53	12 46 17.8	97	254
11 25	11 22 41.8	96	236	11 27 19.2	276	57	12 53 25.3	98	260
11 30	11 27 36.5	96	239	11 32 24.5	277	60	13 00 04.8	100	266
11 35	11 32 31.9	97	243	11 37 29.0	277	64	13 06 20.1	101	272
11 40	11 37 28.0	98	247	11 42 32.9	278	68	13 12 14.0	102	277
11 45	11 42 24.7	99	251	11 47 36.1	279	73	13 17 48.6	103	282
11 50	11 47 22.0	100	255	11 52 38.7	280	77	13 23 05.6	104	287
11 55	11 52 20.0	101	260	11 57 40.7	281	81	13 28 06.8	104	292
12 00	11 57 18.5	102	264	12 02 42.0	282	86	13 32 53.5	105	297
12 05	12 02 17.6	103	269	12 07 42.8	283	90	13 37 27.0	106	301
12 10	12 07 17.3	104	273	12 12 42.9	284	95	13 41 48.4	107	304
12 15	12 12 17.7	104	278	12 17 42.5	285	99	13 45 58.7	107	308
12 20	12 17 18.5	105	282	12 22 41.5	285	104	13 49 58.7	108	311
12 25	12 22 20.0	106	286	12 27 39.9	286	108	13 53 49.1	108	314
12 30	12 27 22.0	107	291	12 32 37.8	287	112	13 57 30.5	109	317
12 35	12 32 24.7	107	295	12 37 35.1	287	116	14 01 03.4	109	319
12 40	12 37 27.8	108	298	12 42 31.8	288	120	14 04 27.8	110	321
12 45	12 42 31.6	108	302	12 47 28.0	288	123	14 07 43.8	110	323
12 50	12 47 36.0	109	305	12 52 23.5	289	127	14 10 50.8	110	324
12 55	12 52 41.0	109	309	12 57 18.5	289	130	14 13 48.1	110	326
13 00	12 57 46.7	109	312	13 02 12.7	289	133	14 16 33.8	110	327
13 05	13 02 53.4	109	314	13 07 06.1	289	135	14 19 04.5	110	328
13 10	13 08 01.3	109	317	13 11 58.2	289	137	14 21 12.5	109	328
13 15	13 13 11.6	109	319	13 16 47.9	289	139	14 22 35.0	109	327
13 16	13 14 14.3	109	319	13 17 45.3	289	139	14 22 39.6	109	327
13 17	13 15 17.4	108	319	13 18 42.1	288	139	14 22 35.1	108	327
13 18	13 16 21.5	108	319	13 19 38.1	288	140	.. .. ..	...	...

LOCAL CIRCUMSTANCES FOR GEOGRAPHIC LOCATIONS

Position		Name of Location	Duration of Totality	Maximum Eclipse					
Latitude	Longitude			Path Width	U.T.	Obscur.	Mag.	Sun's Alt.	Sun's Az.
° ′	° ′	***Uruguay***	m s	km	h m s	%		°	°
−34 32.0	− 56 17.0	Canelones			11 00 19.9	99.8	0.996	1	61
−33 22.0	− 56 31.0	Durazno			10 58 52.8	96.7	0.966	1	61
−34 05.0	− 56 13.0	Florida			10 59 51.0	99.1	0.988	1	61
−34 46.0	− 56 14.0	La Paz	1 33.8	207	11 00 37.8	100.0	1.004	1	61
−34 55.0	− 54 57.0	Maldonado	2 59.1	211	11 01 32.3	100.0	1.020	2	60
−32 22.0	− 54 10.0	Melo			10 59 07.1	97.0	0.968	3	60
−34 22.0	− 55 14.0	Minas	1 48.5	209	11 00 43.8	100.0	1.005	1	60
−34 54.6	− 56 12.8	Montevideo (National Obs.)	2 06.2	208	11 00 48.4	100.0	1.007	1	61
−34 30.0	− 54 20.0	Rocha	2 54.9	212	11 01 25.6	100.0	1.017	2	60
−34 47.0	− 54 55.0	San Carlos	2 54.5	211	11 01 24.1	100.0	1.017	2	60
−34 20.0	− 56 42.0	San Jose de Mayo			10 59 52.7	99.2	0.989	0	61
−34 28.0	− 56 23.0	Santa Lucia			11 00 12.0	99.7	0.995	1	61
−33 13.0	− 54 22.0	Treinta–y–Tres			10 59 56.3	99.1	0.988	3	60
		Brazil							
− 1 27.0	− 48 29.0	Belem			10 45 29.1	9.2	0.182	20	65
−15 45.0	− 47 57.0	Brasilia			10 49 56.4	52.5	0.611	14	60
− 3 45.0	− 38 35.0	Fortaleza			10 55 28.8	25.4	0.365	29	61
−32 34.0	− 53 22.0	Jaguarao			10 59 50.7	98.6	0.983	4	60
−31 45.0	− 52 20.0	Pelotas			10 59 38.6	97.7	0.974	5	59
−30 03.2	− 51 07.6	Porto Alegre (Morro Santana Obs.)			10 58 42.3	94.3	0.946	6	59
− 8 06.0	− 34 53.0	Recife			11 01 40.4	43.3	0.531	32	56
−22 53.7	− 43 13.4	Rio de Janeiro (National Obs.)			10 59 16.7	82.7	0.854	16	55
−32 03.0	− 52 08.0	Rio Grande			11 00 06.5	98.7	0.984	5	59
−12 58.0	− 38 29.0	Salvador			10 58 34.8	55.6	0.636	25	56
−33 31.0	− 53 22.0	Santa Vitoria do Palmar	1 49.4	211	11 00 54.6	100.0	1.005	3	59
−23 33.0	− 46 39.0	Sao Paulo			10 56 22.1	80.3	0.835	13	57
		Other South America							
−25 15.0	− 57 40.0	Asuncion, Paraguay			10 50 24.7	70.2	0.756	2	63
−34 37.3	− 58 21.3	Buenos Aires, Arg. (Naval Obs.)			.. ..	... .	. ...	...	...
−31 25.3	− 64 11.8	Cordoba, Arg. (Cordoba Obs.)			.. ..	... .	. ...	...	...
−16 30.0	− 68 10.0	La Paz, Bolivia			.. ..	... .	. ...	...	...
−34 52.0	− 57 55.0	La Plata, Argentina			.. ..	... .	. ...	...	...
−38 00.0	− 57 32.0	Mar del Plata, Argentina			.. ..	... .	. ...	...	...
−35 20.7	− 57 17.2	Punta Indio, Arg. (La Plata Obs.)			.. ..	... .	. ...	...	...
−22 52.0	− 66 41.0	Rosario, Argentina			.. ..	... .	. ...	...	...
−33 30.0	− 70 40.0	Santiago, Chile			.. ..	... .	. ...	...	...
		Africa							
+ 5 19.0	− 4 01.0	Abidjan, Ivory Coast			12 03 04.0	8.6	0.173	72	12
+ 5 33.0	− 0 15.0	Accra, Ghana			12 11 53.0	5.6	0.131	72	355
−33 56.1	+ 18 28.7	Cape Town, S. Africa (Ast. Obs.)			13 12 01.9	88.6	0.899	24	324
−29 53.0	+ 31 00.0	Durban, S. Africa			13 27 38.2	53.5	0.619	17	311
−26 10.0	+ 28 02.0	Johannesburg, S. Africa			13 25 04.5	47.5	0.568	22	312
− 4 18.0	+ 15 18.0	Kinshasa, Zaire			12 55 25.7	9.8	0.190	51	316
+ 6 27.0	+ 3 28.0	Lagos, Nigeria			12 19 44.1	1.8	0.060	72	337
− 8 50.0	+ 13 15.0	Luanda, Angola			12 55 14.5	24.1	0.352	49	322
−25 58.0	+ 32 35.0	Maputo, Mozambique			13 29 38.0	38.8	0.492	18	308
−25 45.0	+ 28 12.0	Pretoria, S. Africa			13 25 15.9	45.9	0.554	22	312
−17 43.0	+ 31 05.0	Salisbury, Zimbabwe			13 27 14.7	18.1	0.289	25	307
−22 34.0	+ 17 06.0	Windhoek, Namibia			13 09 45.4	57.4	0.650	34	322
		South Atlantic Islands							
− 7 57.0	− 14 22.0	Ascension Island			11 45 07.2	53.9	0.621	54	30
−15 58.0	− 5 43.0	St. Helena Island			12 14 28.6	74.9	0.791	51	4
−20 30.0	− 29 00.0	Trinidad Island			11 18 53.4	90.4	0.913	31	44

Assumed to be sea level, except observatories.

Names and spelling are not authoritative, nor do they imply any official recognition of status.

No correction for elevation, limb or refraction included.

LOCAL CIRCUMSTANCES FOR GEOGRAPHIC LOCATIONS

Position		First Contact			Second Contact			Third Contact			Fourth Contact		
Latitude	Longitude	U.T.	*P*	*V*	U.T.	*P*	*V*	U.T.	*P*	*V*	U.T.	*P*	*V*
° ′	° ′	h m s	°	°	h m s	°	°	h m s	°	°	h m s	°	°
−34 32.0	− 56 17.0	.. ..	...	...							12 07 59.2	94	230
−33 22.0	− 56 31.0	.. ..	...	...							12 06 19.5	95	230
−34 05.0	− 56 13.0	.. ..	...	...							12 07 31.7	94	230
−34 46.0	− 56 14.0	.. ..	...	...	10 59 51.0	33	161	11 01 24.9	330	98	12 08 19.3	93	230
−34 55.0	− 54 57.0	.. ..	...	...	11 00 03.1	82	211	11 03 02.2	282	51	12 09 59.1	93	230
−32 22.0	− 54 10.0	.. ..	...	...							12 07 58.5	95	231
−34 22.0	− 55 14.0	.. ..	...	...	10 59 49.8	38	167	11 01 38.3	325	93	12 09 00.5	93	230
−34 54.6	− 56 12.8	.. ..	...	...	10 59 45.6	46	175	11 01 51.8	317	85	12 08 30.8	93	230
−34 30.0	− 54 20.0	.. ..	...	...	10 59 58.4	74	203	11 02 53.3	289	58	12 10 14.6	93	230
−34 47.0	− 54 55.0	.. ..	...	...	10 59 57.1	75	204	11 02 51.7	288	57	12 09 52.2	93	230
−34 20.0	− 56 42.0	.. ..	...	...							12 07 16.7	94	230
−34 28.0	− 56 23.0	.. ..	...	...							12 07 47.7	94	230
−33 13.0	− 54 22.0	.. ..	...	...							12 08 43.0	94	231
− 1 27.0	− 48 29.0	10 08 32.8	214	311							11 25 15.5	146	251
−15 45.0	− 47 57.0	9 51 12.0	246	354							11 56 32.3	115	239
− 3 45.0	− 38 35.0	10 01 24.1	230	332							11 56 01.1	133	252
−32 34.0	− 53 22.0	.. ..	...	...							12 09 14.0	95	231
−31 45.0	− 52 20.0	.. ..	...	...							12 09 40.2	95	232
−30 03.2	− 51 07.6	.. ..	...	...							12 09 25.9	97	232
− 8 06.0	− 34 53.0	9 57 38.4	242	350							12 14 41.1	123	254
−22 53.7	− 43 13.4	9 53 04.6	261	18							12 15 03.7	103	239
−32 03.0	− 52 08.0	.. ..	...	...							12 10 17.0	95	232
−12 58.0	− 38 29.0	9 53 32.5	248	358							12 13 10.4	116	248
−33 31.0	− 53 22.0	.. ..	...	...	11 00 00.1	38	166	11 01 49.6	326	94	12 10 19.3	94	231
−23 33.0	− 46 39.0	.. ..	...	...							12 09 15.5	103	237
−25 15.0	− 57 40.0	.. ..	...	...							11 54 39.4	106	232
−34 37.3	− 58 21.3	.. ..	...	...							12 05 49.6	95	229
−31 25.3	− 64 11.8	.. ..	...	...							11 56 03.4	101	230
−16 30.0	− 68 10.0	.. ..	...	...							11 28 50.5	128	239
−34 52.0	− 57 55.0	.. ..	...	...							12 06 35.4	94	229
−38 00.0	− 57 32.0	.. ..	...	...							12 10 45.6	90	229
−35 20.7	− 57 17.2	.. ..	...	...	.. ..	...	...	.. ..	...	...	12 07 50.7	93	229
−22 52.0	− 66 41.0	.. ..	...	...							11 41 24.2	116	233
−33 30.0	− 70 40.0	.. ..	...	...							11 54 02.1	102	229
+ 5 19.0	− 4 01.0	11 11 07.0	227	2							12 54 52.4	164	11
+ 5 33.0	− 0 15.0	11 26 10.7	225	16							12 56 51.6	170	28
−33 56.1	+ 18 28.7	11 51 59.6	282	117							14 23 55.2	118	341
−29 53.0	+ 31 00.0	12 19 53.1	268	122							14 28 28.7	134	8
−26 10.0	+ 28 02.0	12 16 43.2	265	118							14 26 15.8	138	13
− 4 18.0	+ 15 18.0	12 04 11.4	237	88							13 43 05.5	168	48
+ 6 27.0	+ 3 28.0	11 48 35.1	218	37							12 50 19.2	180	44
− 8 50.0	+ 13 15.0	11 47 21.4	250	87							13 57 06.2	154	31
−25 58.0	+ 32 35.0	12 27 06.7	260	120							14 26 00.2	143	20
−25 45.0	+ 28 12.0	12 17 28.3	264	118							14 25 58.5	139	14
−17 43.0	+ 31 05.0	12 35 08.9	247	113							14 14 50.6	158	41
−22 34.0	+ 17 06.0	11 50 36.0	269	107							14 20 13.7	134	5
− 7 57.0	− 14 22.0	10 22 33.8	254	18							13 13 06.7	128	314
−15 58.0	− 5 43.0	10 42 45.7	269	53							13 44 57.5	122	330
−20 30.0	− 29 00.0	10 01 47.7	267	29							12 46 51.3	104	260

Dot leaders indicate the phenomenon occurs below the horizon. Blanks indicate the phenomenon does not occur for the location.

SURFACE PATH OF THE TOTAL PHASE OVER LAND

Longitude	Latitude of: Northern Limit	Latitude of: Central Line	Latitude of: Southern Limit	Universal Time at: Northern Limit	Universal Time at: Central Line	Universal Time at: Southern Limit	On Central Line: Maximum Duration	On Central Line: Path Width	On Central Line: Sun's Alt.	On Central Line: Az.
° ′	° ′	° ′	° ′	h m s	h m s	h m s	m s	km	°	°
− 55 00	−34 02.9	.. .. .	.. .. .	11 00 30.4	.. ..	.. ..	.. .. .	...	..	..
− 54 30	−33 49.4	.. ...	.. .. .	11 00 34.9	.. ..	.. ..	.. .. .	...	..	..
− 54 00	−33 35.9	.. .. .	.. .. .	11 00 39.3	.. ..	.. ..	.. .. .	...	..	..
− 53 30	−33 22.4	.. .. .	.. .. .	11 00 43.7	.. ..	.. ..	.. .. .	...	..	..
− 53 00	−33 08.9	.. .. .	.. .. .	11 00 48.1	.. ..	.. ..	.. .. .	...	..	..
− 52 30	−32 55.5	−34 00.8	.. .. .	11 00 52.5	11 02 04.9	.. ..	3 08.3	215	4	59
− 52 00	−32 42.0	−33 47.6	.. .. .	11 00 56.9	11 02 11.4	.. ..	3 09.7	216	4	58
− 51 30	−32 28.5	−33 34.4	−34 41.4	11 01 01.9	11 02 18.0	11 03 35.1	3 11.1	217	5	58
− 51 00	−32 15.2	−33 21.2	−34 28.4	11 01 08.8	11 02 24.5	11 03 42.8	3 12.5	218	5	58
− 50 30	−32 01.9	−33 08.0	−34 15.4	11 01 16.9	11 02 31.3	11 03 50.4	3 13.9	218	6	57
− 50 00	−31 48.7	−32 55.0	−34 02.4	11 01 26.3	11 02 39.9	11 03 58.1	3 15.3	219	6	57
− 49 30	−31 35.6	−32 42.0	−33 49.6	11 01 36.3	11 02 49.4	11 04 07.0	3 16.8	220	7	57
− 49 00	−31 22.5	−32 29.0	−33 36.8	11 01 46.7	11 02 59.9	11 04 17.1	3 18.3	221	7	57
− 48 30	−31 09.4	−32 16.1	−33 24.0	11 01 58.1	11 03 11.0	11 04 28.1	3 19.8	222	8	56
− 48 00	−30 56.4	−32 03.3	−33 11.4	11 02 10.2	11 03 22.9	11 04 39.8	3 21.3	223	8	56
− 47 30	−30 43.5	−31 50.5	−32 58.8	11 02 23.1	11 03 35.7	11 04 52.4	3 22.9	223	9	56
− 47 00	−30 30.6	−31 37.8	−32 46.2	11 02 36.9	11 03 49.2	11 05 05.8	3 24.4	224	9	55
− 46 30	−30 17.9	−31 25.2	−32 33.8	11 02 51.5	11 04 03.7	11 05 20.0	3 26.0	225	10	55
− 46 00	−30 05.1	−31 12.7	−32 21.4	11 03 07.0	11 04 19.0	11 05 35.1	3 27.6	226	10	55
− 45 30	−29 52.5	−31 00.2	−32 09.1	11 03 23.4	11 04 35.1	11 05 51.1	3 29.3	227	11	54
− 45 00	−29 39.9	−30 47.8	−31 56.9	11 03 40.6	11 04 52.2	11 06 07.9	3 30.9	228	11	54

CORRECTIONS TO U.T. AND LATITUDE FOR ELEVATIONS ABOVE SEA LEVEL

Longitude	Latitude Corr.	U.T. Corr.	Longitude	Latitude Corr.	U.T. Corr.	Longitude	Latitude Corr.	U.T. Corr.
° ′	″	s	° ′	″	s	° ′	″	s
− 52 30	+9.589	−0.401	− 49 30	+9.738	−0.447	− 46 30	+9.778	−0.450
− 52 00	+9.732	−0.443	− 49 00	+9.764	−0.454	− 46 00	+9.782	−0.449
− 51 30	+9.875	−0.484	− 48 30	+9.760	−0.452	− 45 30	+9.791	−0.448
− 51 00	+9.891	−0.490	− 48 00	+9.760	−0.450	− 45 00	+9.798	−0.448
− 50 30	+9.799	−0.467	− 47 30	+9.768	−0.451			
− 50 00	+9.776	−0.459	− 47 00	+9.769	−0.450			

These corrections to latitude and time are to be applied to the corresponding surface data above to correct for elevation. *The units are seconds of arc or seconds of time per thousand feet.*

Example: Elevation 35000 ft. at longitude −52°.

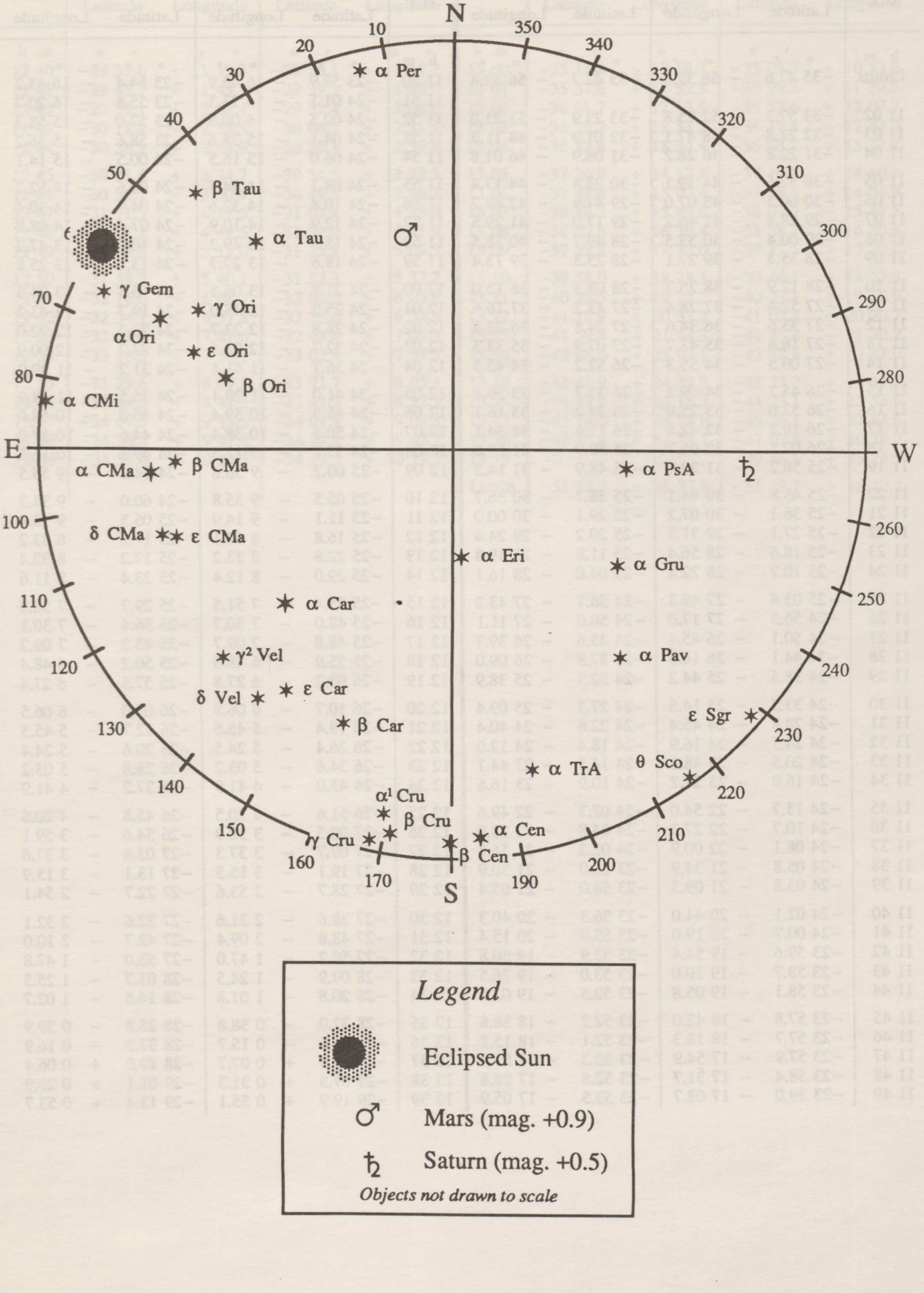
Lat. corr.: $+9''.732 \times 35 = +340''.6 = +5'.7$

Time corr.: $-0^{s}.443 \times 35 = -15^{s}.5$

Hence, for the longitude −52° tabular entry in the surface path table, the two latitude values should be shifted north by 5′.7, and the two times advanced (made earlier) by $15^{s}.5$.

Sky Diagram for Rocha, Uruguay
11h 01m UT

Diagram centered on zenith


N
S
E
W
10
20
30
40
50
70
80
100
110
120
130
140
150
160
170
190
200
210
220
230
240
250
260
280
290
300
310
320
330
340
350
α Per
β Tau
α Tau
γ Gem
γ Ori
α Ori
ε Ori
β Ori
α CMi
α CMa
β CMa
δ CMa
ε CMa
α Car
γ² Vel
δ Vel
ε Car
β Car
α¹ Cru
β Cru
γ Cru
β Cen
α Cen
α TrA
θ Sco
ε Sgr
α Pav
α Gru
α Eri
α PsA
♂
♄
Legend
Eclipsed Sun
♂ Mars (mag. +0.9)
♄ Saturn (mag. +0.5)
Objects not drawn to scale

PATH OF CENTRAL LINE AT FLYING ALTITUDES

U.T.	10000 Ft.		40000 Ft.		U.T.	10000 Ft.		40000 Ft.	
	Latitude	Longitude	Latitude	Longitude		Latitude	Longitude	Latitude	Longitude
h m	° ′	° ′	° ′	° ′	h m	° ′	° ′	° ′	° ′
Limits	−35 47.6	− 56 32.4	−35 42.7	− 56 32.4	11 50	−23 59.9	− 16 45.9	−23 54.4	− 16 43.2
					11 51	−24 01.1	− 16 23.3	−23 55.6	− 16 20.7
11 02	−33 57.3	− 52 25.8	−33 23.9	− 51 21.0	11 52	−24 02.5	− 16 00.9	−23 57.0	− 15 58.3
11 03	−32 21.8	− 48 47.1	−32 01.9	− 48 11.9	11 53	−24 04.1	− 15 38.6	−23 58.6	− 15 36.2
11 04	−31 22.8	− 46 28.2	−31 06.9	− 46 01.8	11 54	−24 06.0	− 15 16.5	−24 00.5	− 15 14.1
11 05	−30 37.6	− 44 39.1	−30 23.8	− 44 17.4	11 55	−24 08.1	− 14 54.5	−24 02.6	− 14 52.2
11 06	−30 00.3	− 43 07.0	−29 47.9	− 42 48.2	11 56	−24 10.4	− 14 32.6	−24 04.9	− 14 30.4
11 07	−29 28.4	− 41 46.2	−29 17.0	− 41 29.5	11 57	−24 12.9	− 14 10.9	−24 07.4	− 14 08.8
11 08	−29 00.4	− 40 33.5	−28 49.7	− 40 18.5	11 58	−24 15.7	− 13 49.2	−24 10.2	− 13 47.2
11 09	−28 35.4	− 39 27.1	−28 25.3	− 39 13.4	11 59	−24 18.6	− 13 27.7	−24 13.1	− 13 25.8
11 10	−28 12.9	− 38 25.7	−28 03.3	− 38 13.0	12 00	−24 21.8	− 13 06.3	−24 16.3	− 13 04.5
11 11	−27 52.4	− 37 28.4	−27 43.2	− 37 16.6	12 01	−24 25.2	− 12 45.0	−24 19.7	− 12 43.2
11 12	−27 33.6	− 36 34.6	−27 24.8	− 36 23.5	12 02	−24 28.8	− 12 23.7	−24 23.3	− 12 22.0
11 13	−27 16.4	− 35 43.7	−27 07.9	− 35 33.3	12 03	−24 32.7	− 12 02.5	−24 27.2	− 12 00.9
11 14	−27 00.5	− 34 55.3	−26 52.2	− 34 45.5	12 04	−24 36.7	− 11 41.4	−24 31.2	− 11 39.9
11 15	−26 45.7	− 34 09.2	−26 37.7	− 33 59.8	12 05	−24 41.0	− 11 20.4	−24 35.5	− 11 18.9
11 16	−26 32.0	− 33 25.0	−26 24.2	− 33 16.1	12 06	−24 45.5	− 10 59.4	−24 40.0	− 10 58.0
11 17	−26 19.2	− 32 42.6	−26 11.6	− 32 34.1	12 07	−24 50.2	− 10 38.4	−24 44.6	− 10 37.2
11 18	−26 07.3	− 32 01.7	−25 59.9	− 31 53.6	12 08	−24 55.1	− 10 17.5	−24 49.5	− 10 16.3
11 19	−25 56.2	− 31 22.3	−25 48.9	− 31 14.5	12 09	−25 00.2	− 9 56.6	−24 54.6	− 9 55.5
11 20	−25 45.8	− 30 44.1	−25 38.7	− 30 36.7	12 10	−25 05.5	− 9 35.8	−24 60.0	− 9 34.7
11 21	−25 36.1	− 30 07.2	−25 29.1	− 30 00.0	12 11	−25 11.1	− 9 14.9	−25 05.5	− 9 13.9
11 22	−25 27.1	− 29 31.3	−25 20.2	− 29 24.4	12 12	−25 16.8	− 8 54.1	−25 11.2	− 8 53.2
11 23	−25 18.6	− 28 56.4	−25 11.8	− 28 49.8	12 13	−25 22.8	− 8 33.2	−25 17.2	− 8 32.4
11 24	−25 10.7	− 28 22.4	−25 04.0	− 28 16.1	12 14	−25 29.0	− 8 12.4	−25 23.4	− 8 11.6
11 25	−25 03.4	− 27 49.3	−24 56.7	− 27 43.2	12 15	−25 35.4	− 7 51.5	−25 29.7	− 7 50.9
11 26	−24 56.5	− 27 17.0	−24 50.0	− 27 11.1	12 16	−25 42.0	− 7 30.7	−25 36.4	− 7 30.1
11 27	−24 50.1	− 26 45.4	−24 43.6	− 26 39.7	12 17	−25 48.8	− 7 09.7	−25 43.2	− 7 09.2
11 28	−24 44.1	− 26 14.5	−24 37.8	− 26 09.0	12 18	−25 55.9	− 6 48.8	−25 50.2	− 6 48.4
11 29	−24 38.6	− 25 44.2	−24 32.3	− 25 38.9	12 19	−26 03.2	− 6 27.8	−25 57.5	− 6 27.4
11 30	−24 33.5	− 25 14.5	−24 27.3	− 25 09.4	12 20	−26 10.7	− 6 06.8	−26 05.0	− 6 06.5
11 31	−24 28.8	− 24 45.4	−24 22.6	− 24 40.4	12 21	−26 18.4	− 5 45.6	−26 12.7	− 5 45.5
11 32	−24 24.5	− 24 16.9	−24 18.4	− 24 12.0	12 22	−26 26.4	− 5 24.5	−26 20.6	− 5 24.4
11 33	−24 20.5	− 23 48.8	−24 14.5	− 23 44.1	12 23	−26 34.6	− 5 03.2	−26 28.8	− 5 03.2
11 34	−24 16.9	− 23 21.2	−24 10.9	− 23 16.6	12 24	−26 43.0	− 4 41.9	−26 37.2	− 4 41.9
11 35	−24 13.7	− 22 54.0	−24 07.7	− 22 49.6	12 25	−26 51.6	− 4 20.5	−26 45.8	− 4 20.6
11 36	−24 10.7	− 22 27.3	−24 04.8	− 22 23.0	12 26	−27 00.5	− 3 58.9	−26 54.6	− 3 59.1
11 37	−24 08.1	− 22 00.9	−24 02.2	− 21 56.8	12 27	−27 09.7	− 3 37.3	−27 03.8	− 3 37.6
11 38	−24 05.8	− 21 34.9	−23 60.0	− 21 30.9	12 28	−27 19.1	− 3 15.5	−27 13.1	− 3 15.9
11 39	−24 03.8	− 21 09.3	−23 58.0	− 21 05.4	12 29	−27 28.7	− 2 53.6	−27 22.7	− 2 54.1
11 40	−24 02.1	− 20 44.0	−23 56.3	− 20 40.3	12 30	−27 38.6	− 2 31.6	−27 32.6	− 2 32.1
11 41	−24 00.7	− 20 19.0	−23 55.0	− 20 15.4	12 31	−27 48.8	− 2 09.4	−27 42.7	− 2 10.0
11 42	−23 59.6	− 19 54.4	−23 53.9	− 19 50.8	12 32	−27 59.2	− 1 47.0	−27 53.0	− 1 47.8
11 43	−23 58.7	− 19 30.0	−23 53.0	− 19 26.5	12 33	−28 09.9	− 1 24.5	−28 03.7	− 1 25.3
11 44	−23 58.1	− 19 05.8	−23 52.5	− 19 02.5	12 34	−28 20.8	− 1 01.8	−28 14.6	− 1 02.7
11 45	−23 57.8	− 18 42.0	−23 52.2	− 18 38.8	12 35	−28 32.0	− 0 38.8	−28 25.8	− 0 39.9
11 46	−23 57.7	− 18 18.3	−23 52.1	− 18 15.2	12 36	−28 43.6	− 0 15.7	−28 37.3	− 0 16.9
11 47	−23 57.9	− 17 54.9	−23 52.3	− 17 51.9	12 37	−28 55.4	+ 0 07.7	−28 49.0	+ 0 06.4
11 48	−23 58.4	− 17 31.7	−23 52.8	− 17 28.8	12 38	−29 07.5	+ 0 31.3	−29 01.1	+ 0 29.9
11 49	−23 59.0	− 17 08.7	−23 53.5	− 17 05.9	12 39	−29 19.9	+ 0 55.1	−29 13.4	+ 0 53.7

PATH OF CENTRAL LINE AT FLYING ALTITUDES

U.T.	10000 Ft.		40000 Ft.		U.T.	10000 Ft.		40000 Ft.	
	Latitude	Longitude	Latitude	Longitude		Latitude	Longitude	Latitude	Longitude
h m	° ′	° ′	° ′	° ′	h m	° ′	° ′	° ′	° ′
12 40	−29 32.6	+ 1 19.3	−29 26.1	+ 1 17.7	13 00	−35 14.4	+ 10 58.3	−35 05.7	+ 10 53.2
12 41	−29 45.7	+ 1 43.7	−29 39.1	+ 1 42.0	13 01	−35 37.6	+ 11 35.3	−35 28.7	+ 11 29.8
12 42	−29 59.1	+ 2 08.4	−29 52.4	+ 2 06.6	13 02	−36 01.7	+ 12 13.5	−35 52.6	+ 12 07.7
12 43	−30 12.8	+ 2 33.5	−30 06.1	+ 2 31.5	13 03	−36 26.7	+ 12 53.2	−36 17.4	+ 12 47.0
12 44	−30 26.9	+ 2 58.9	−30 20.1	+ 2 56.8	13 04	−36 52.8	+ 13 34.4	−36 43.2	+ 13 27.9
12 45	−30 41.4	+ 3 24.7	−30 34.5	+ 3 22.5	13 05	−37 20.0	+ 14 17.4	−37 10.1	+ 14 10.4
12 46	−30 56.2	+ 3 50.9	−30 49.3	+ 3 48.5	13 06	−37 48.4	+ 15 02.4	−37 38.3	+ 14 54.9
12 47	−31 11.5	+ 4 17.5	−31 04.4	+ 4 15.0	13 07	−38 18.2	+ 15 49.6	−38 07.7	+ 15 41.5
12 48	−31 27.1	+ 4 44.5	−31 20.0	+ 4 41.9	13 08	−38 49.6	+ 16 39.4	−38 38.7	+ 16 30.6
12 49	−31 43.2	+ 5 12.0	−31 35.9	+ 5 09.3	13 09	−39 22.8	+ 17 32.0	−39 11.5	+ 17 22.6
12 50	−31 59.7	+ 5 40.1	−31 52.3	+ 5 37.2	13 10	−39 58.0	+ 18 28.1	−39 46.1	+ 18 17.8
12 51	−32 16.6	+ 6 08.7	−32 09.2	+ 6 05.6	13 11	−40 35.5	+ 19 28.2	−40 23.1	+ 19 16.9
12 52	−32 34.1	+ 6 37.8	−32 26.6	+ 6 34.6	13 12	−41 15.9	+ 20 33.2	−41 02.8	+ 20 20.7
12 53	−32 52.0	+ 7 07.6	−32 44.4	+ 7 04.2	13 13	−41 59.8	+ 21 44.3	−41 45.8	+ 21 30.2
12 54	−33 10.5	+ 7 38.1	−33 02.8	+ 7 34.5	13 14	−42 48.0	+ 23 03.1	−42 32.8	+ 22 47.0
12 55	−33 29.6	+ 8 09.3	−33 21.7	+ 8 05.4	13 15	−43 41.9	+ 24 32.3	−43 25.2	+ 24 13.5
12 56	−33 49.2	+ 8 41.3	−33 41.2	+ 8 37.2	13 16	−44 43.9	+ 26 16.3	−44 25.1	+ 25 53.6
12 57	−34 09.5	+ 9 14.1	−34 01.3	+ 9 09.8	13 17	−45 58.5	+ 28 24.0	−45 36.1	+ 27 54.6
12 58	−34 30.4	+ 9 47.8	−34 22.1	+ 9 43.2	13 18	−47 37.9	+ 31 18.7	−47 07.8	+ 30 34.7
12 59	−34 52.0	+ 10 22.5	−34 43.5	+ 10 17.7	13 19	.. .. .	.. .. .	−49 46.5	+ 35 24.5
					Limits	−51 32.5	+ 38 37.9	−51 28.2	+ 38 40.2

LIMB CORRECTIONS

The information below is based largely on the article, "Correcting Predictions of Solar Eclipse Contact Times for the Effects of Lunar Limb Irregularities", *J. Brit. Astron. Assoc.* 1983, **93**, 6, pp. 241-246, by David Herald of Canberra, A. C. T., Australia. Mr. Herald's charts for this eclipse appear on the next page.

For locations in the central path of a solar eclipse, predicted times of second and third contacts are computed on the assumption that the Moon is a smooth circular body. However, in the strict sense this is not true, and, in particular, the irregular limb of the Moon introduces a change into those predicted contact times which may potentially amount to several seconds at locations well away from the central line. The change is caused by two different effects of the irregular limb.

First, the position and motion of the Moon are calculated from gravitational theory which deals only with a point mass, or center of gravity. However, the observed eclipse phenomena are caused by the apparent figure, and the Moon is such an irregular body that the centers of figure and mass do not coincide. Therefore, in predicting the contacts, corrections have been applied to the lunar ephemeris for the offset of the center of figure from the center of mass or motion (see *Elements of the Eclipse*), and a mean lunar profile radius, *k*, has been used in the calculations.

The predicted second and third contacts are defined as the instants at which the solar limb is tangential to the mean lunar limb, but does not intersect it at any point. However, applying this definition to the irregular true lunar limb, one can see by inspection of the profiles (pages 30 and 48) that for any given point of predicted contact on the smooth mean limb, there is some irregular valley feature in the vicinity whose innermost (deepest) point will define the true contact. Then the operational definition of the second and third contacts is whether or not any light from the photosphere is visible. In general, but not always, second contact will be later than predicted, and third contact earlier.

The plot of the lunar limb shows the difference between the true limb and the mean limb exaggerated 70 to 1 on the radial scale. If the solar limb relative to the mean lunar limb is plotted using the same exaggerated radial scale, at the time of predicted second or third contact, it forms an epicyclic curve separating from the lunar limb rapidly with position angle away from the predicted contact point. Furthermore, if this epicyclic curve representing the solar limb is plotted for a sequence of times at small intervals, the sequence of curves progresses essentially along the radial direction from the mean limb at the contact point. Hence, in effect, when this epicyclic curve is shifted radially so as to be tangent to the true irregular limb at some valley point which may lie well off the cited radius, the displacement of the solar limb from the predicted contact point, in seconds of arc, is ascertained for that position angle. The locus of such displacements for all position angles is a curve representing the displacement of the solar limb from the mean lunar limb at the true time it contacts the true lunar limb at any given position angle of contact. In other words, it is the operational lunar limb for predicting contact times.

To use this displacement curve to correct predicted contact times for the mean limb, it is necessary to relate the displacement in seconds of arc to a time interval. This is most conveniently achieved by plotting along with the displacement curve already described another curve representing the locus of the displacement of the solar limb at each position angle at some specified constant time interval (e.g. 10 seconds) from the mean-limb contact time. The ratio of the displacement of the solar limb at true contact to the displacement in a constant time interval then gives directly the correction to be applied to account for the effect of the lunar limb features.

The first curve, for displacement from predicted contact, is nearly the same for the entire eclipse track, but the curve for displacement of the solar limb in 10 seconds is location-dependent and should be calculated for each major observing region in the path.

Overleaf is a pair of correction diagrams for Uruguay. They are oriented to match the limb profile diagram, so that north is up and east is left. Conceptually, time flows left to right. The left-hand diagram is for second contact, the right hand one is for third contact. The vertical line in each diagram represents the instant of the mean, smooth-limb, predicted contact. The smooth curved lines represent the relative displacement of the solar limb in 10 seconds. Position angles are marked on the vertical. The irregular curves running vertically represent the displacement at the instant of contact with the true, irregular limb, i.e., the operational lunar limb.

To get the correction for a specific location, first obtain the predicted times and position angles of the second and third contacts, either from the tables or by estimation as described elsewhere. On the vertical lines, find each position angle and lay a ruler from from that point to the associated point on the smooth solar limb displacement curve. Measure the distance between those two points, and the distance from the vertical line to the irregular displacement curve. Divide the second measure by the first and multiply by 10 to get the correction in seconds of time. For second contact, if the two curve points are on the same side of the vertical line, add the correction to the predicted time; otherwise, subtract. For third contact, if the two curve points are on the same side of the vertical line, subtract the correction from the predicted contact time; otherwise, add it.

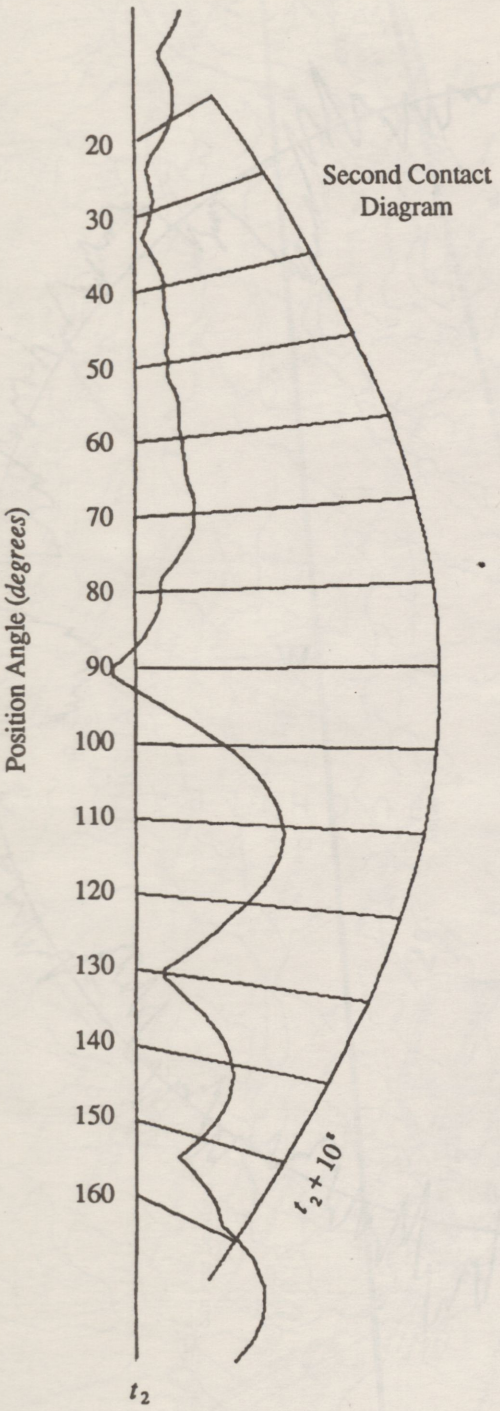
During the time interval between predicted and corrected times, Baily's Bead effects may appear.

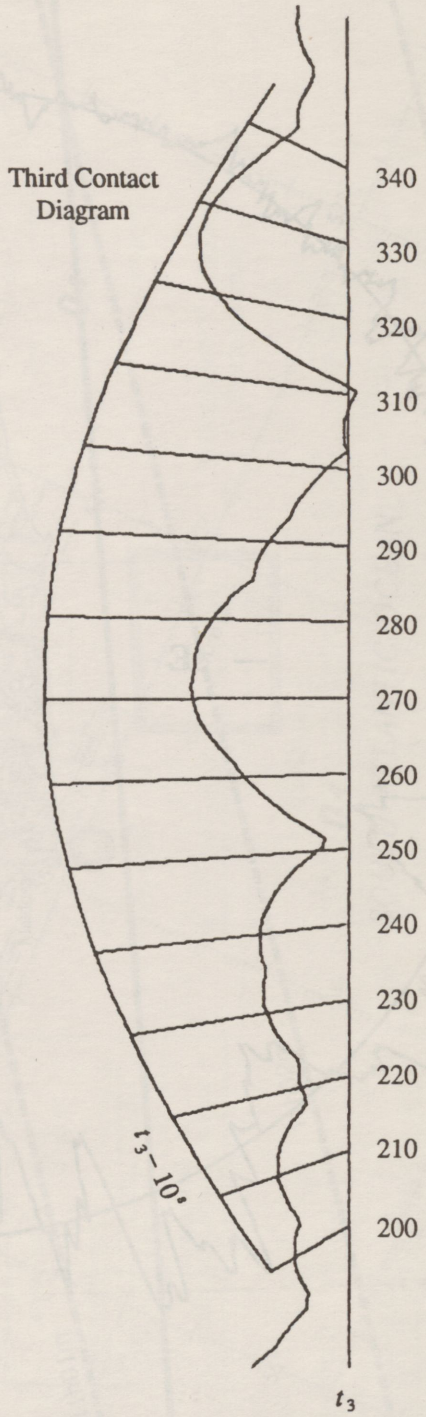
EXAMPLE: At Maldonado, Uruguay, from the Local Circumstances table, the position angles are 82° (second contact) and 282° (third contact). On the second contact (left) diagram, for angle 82°, the displacement curve lies about 5/62 of the distance to the solar limb curve, both curves on the same side of the vertical line; hence, the time correction is $+0^{\mathrm{s}}.8$ Similarly, on the third contact (right) diagram, for angle 282°, the ratio of the distances is approximately 26/62 with both curves on the same side of the vertical line; thus, the time correction is $-4^{\mathrm{s}}.2$. Applying these corrections to the predicted times gives 11h 00m 03.9s UT for second contact and 11h 02m 58.0s UT for third contact.

LUNAR PROFILE CORRECTION DIAGRAMS

Uruguay

David Herald
P. O. Box 254
Woden, A. C. T. 2606
AUSTRALIA

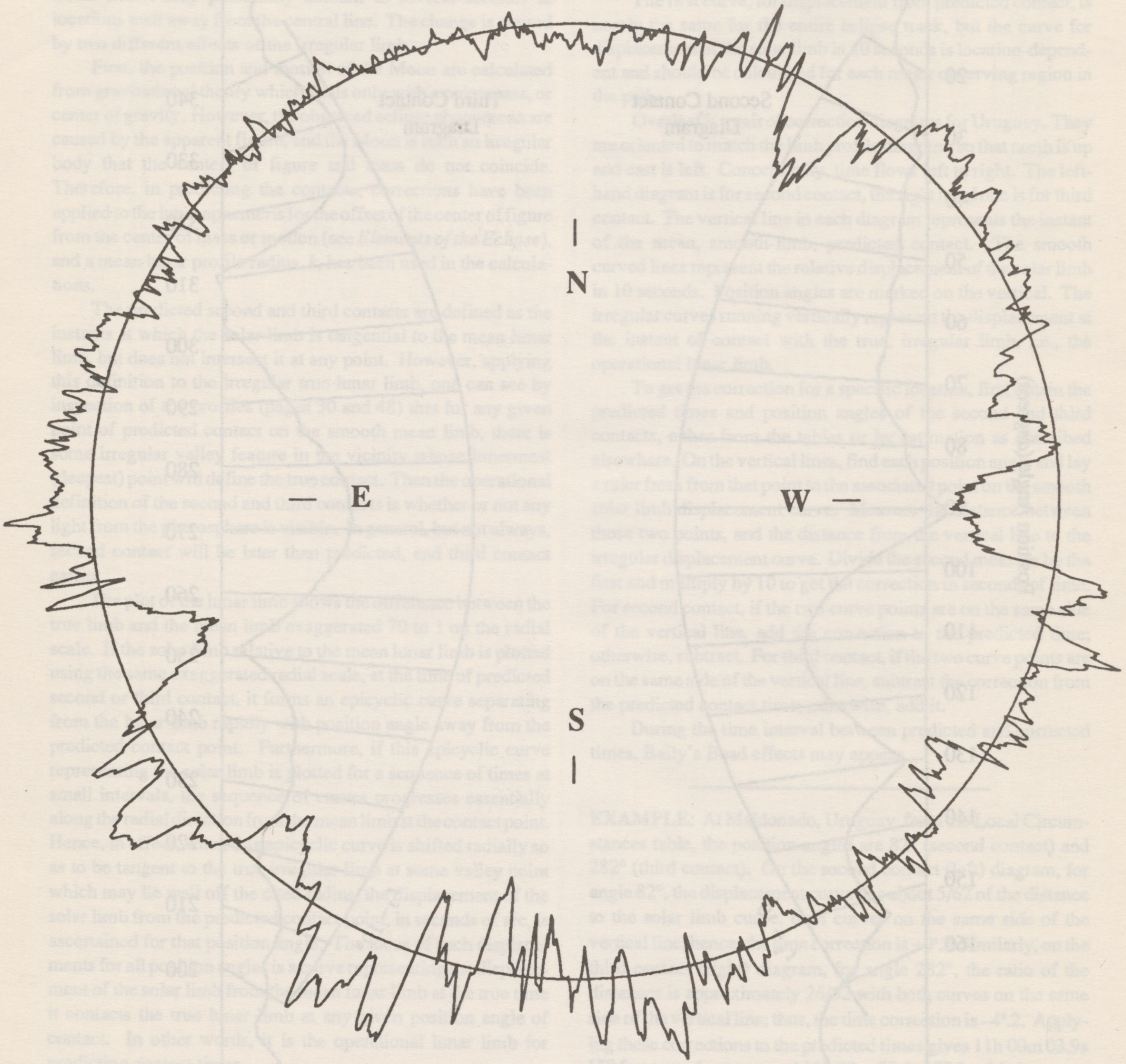


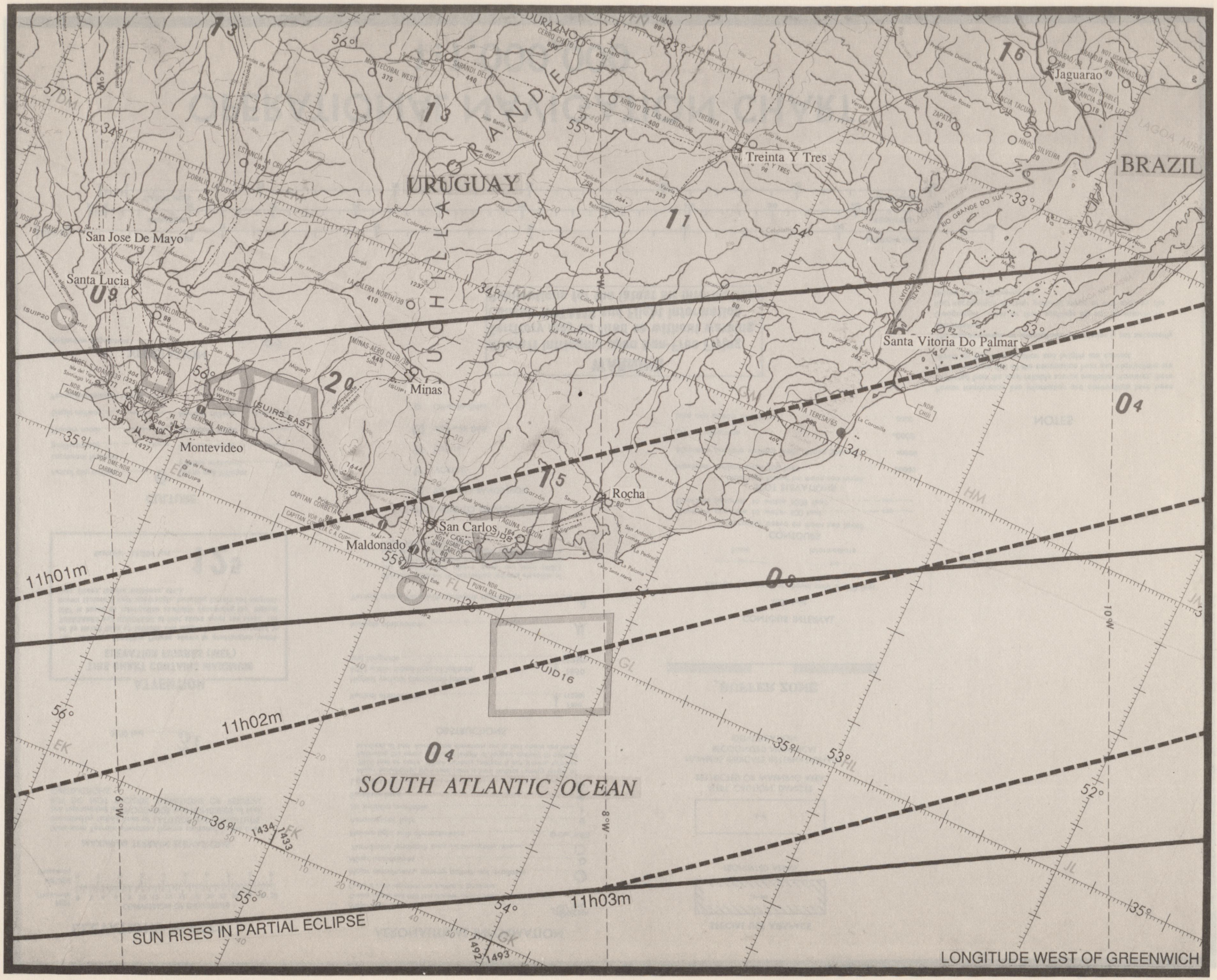


LUNAR LIMB PROFILE

Radial Scale at Limb: approx. 4 arcsec/inch

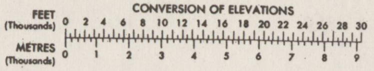
true limb: *irregular curve*
mean limb: *smooth curve*




URUGUAY
BRAZIL
SOUTH ATLANTIC OCEAN
Jaguarao
Treinta Y Tres
San Jose De Mayo
Santa Lucia
Minas
Montevideo
Maldonado
San Carlos
Rocha
Santa Vitoria Do Palmar
11h01m
11h02m
11h03m
SUN RISES IN PARTIAL ECLIPSE
33°
34°
35°
36°
52°
53°
54°
55°
56°
57°
LONGITUDE WEST OF GREENWICH

ELEVATIONS IN FEET

CONVERSION OF ELEVATIONS



MAXIMUM TERRAIN ELEVATIONS

Maximum Terrain elevation figures centered in the area bounded by ticked lines of LATITUDE and LONGITUDE, are represented in THOUSANDS and HUNDREDS of feet, BUT DO NOT INCLUDE ELEVATIONS OF VERTICAL OBSTRUCTIONS.

3100 feet 31

ATTENTION

THIS CHART CONTAINS MAXIMUM ELEVATION FIGURES (MEF)

The Maximum Elevation Figures shown in quadrangles bounded by ticked lines of latitude and longitude are represented in THOUSANDS and HUNDREDS of feet above mean sea level. The MEF is based on information available concerning the highest known feature in each quadrangle, including terrain and obstructions, (trees, towers, antennas, etc.).

Example: 12,500 feet .... 12^5

CULTURE

Actual city outline .... ▨
Towns and Villages (outline unknown)........... ☐ ▫
Landmark features (unillustrated)..................... • tower
Dual lane roads........ ═══
Primary roads.................. ───
Secondary roads .... ───
Single railway.......... ─┼──┼─
Multiple railway .... ─┼──╫─
Power transmission line •-----

VEGETATION

Distinctive vegetation.. ▨

AERONAUTICAL INFORMATION

Major aerodromes .... J ⌀ EDNA 920
Runway pattern and 6000 foot diameter circle is shown at 1:500,000 scale.
Centre of circle represents true position of aerodrome.

Major aerodromes, runway pattern not available .... ○
Minor aerodromes .... ○
Aerodrome landmark Status and Serviceability Unknown.................. ◌
Marine light with characteristics .... ● Occ WRG
Aeronautical light .... ★
Jet facilities available .... J
Seaplane base .... ⊕
Lightship .... ⚓

Major aerodromes portrayed have a hard surface runway length of 3000 feet or more. When runway pattern is not shown, number following the name indicates length of longest runway to nearest hundreds of feet. Aerodrome elevations are in feet above sea level.

OBSTRUCTIONS

Vertical obstructions .... ⅄ 1850 (1250)

Highest vertical obstruction (above MSL) within ticked lines of latitude and longitude .... ⅄ 1850 (1250)

Multiple obstructions .... ⅄⅄

Vertical obstructions with landmark significance .... ⅄

Numbers adjacent to obstruction indicate elevation of top of obstruction above mean sea level (MSL). Numerals in parenthesis indicate height above ground level (AGL). Vertical obstructions under 200 feet in height (AGL) are not shown.

RADIO AIDS TO NAVIGATION

⊙ VHF OMNI RANGE (VOR)
⊗ VORTAC
▽ TACAN
⊡ VOR with DME
⊙ Other facilities

WARNING

Aircraft infringing upon Non-Free Flying Territory may be fired on without warning. Consult NOTAMS and Flight Information Publications for the latest air information.

SPECIAL USE AIRSPACE

▨ P-16

PROHIBITED AREAS

☐ A-4

ALERT, CAUTION, DANGER
RESTRICTED OR WARNING AREA

NUMBERS INDICATE INTERNATIONALLY
RECOGNIZED NUMERICAL
IDENTIFICATION

BUFFER ZONE

▨▨▨ ─── ▨▨▨

CONTOUR INTERVAL

1000 feet

Intermediate contour shown only at 500 feet

——1000—— Basic
- - - 500 - - - Intermediate

CONTOURS

(Accuracy based on mean sea level)

Contours accurate to within 500 feet . . . . ——1000——
Contours accurate to within 1000 feet . . . . . . — —1000— —

SPOT ELEVATIONS

(Accuracy based on mean sea level)

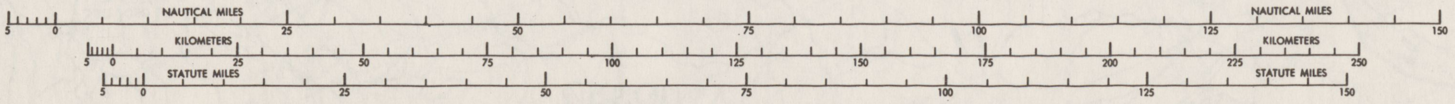
Maximum vertical error 100 feet. . . . . •0000
Maximum possible vertical error (None Shown). . . . x0000
Critical elevation . . . . •0000
Lake and stream elevation 0000

NOTES

Power transmission line information and obstructions have been extracted from the most reliable source available. However, there is no assurance that all the transmission lines and obstructions are shown or that their location and heights are correct.

The representation of international boundaries is not necessarily authoritative.

Geographic names or their spellings do not necessarily reflect recognition of their political status of and area by the United States Government.



OPERATIONAL NAVIGATION CHART

1:1,000,000

*U.S. GOVERNMENT PRINTING OFFICE: 1991—522-739/40189

DEPARTMENT OF THE NAVY

U. S. NAVAL OBSERVATORY
WASHINGTON, DC 20392

OFFICIAL BUSINESS
PENALTY FOR PRIVATE USE, $300

4th CLASS MAIL
POSTAGE AND FEES PAID
DEPARTMENT OF THE NAVY
PERMIT NO. G–9